



## **Guidelines for the Use of Antiretroviral Agents in HIV-1-Infected Adults and Adolescents**

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# Guidelines for the Use of Antiretroviral Agents in HIV-1-Infected Adults and Adolescents



Developed by the DHHS Panel on Antiretroviral Guidelines for Adults and Adolescents – A Working Group of the Office of AIDS Research Advisory Council (OARAC)

## How to Cite the Adult and Adolescent Guidelines:

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It is emphasized that concepts relevant to HIV management evolve rapidly. The Panel has a mechanism to update recommendations on a regular basis, and the most recent information is available on the *AIDSinfo* Web site (<http://aidsinfo.nih.gov>).

## What's New in the Guidelines? (Last updated January 28, 2016; last reviewed January 28, 2016)

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Revisions to the April 8, 2015, version of the guidelines are largely based on findings from two large, randomized controlled trials that addressed the optimal time to initiate antiretroviral therapy (ART)—START (Strategic Timing of Antiretroviral Therapy) and TEMPRANO. Both studies demonstrated approximately a 50% reduction in morbidity and mortality among HIV-infected individuals with CD4 T lymphocyte cell (CD4) counts >500 cells/mm<sup>3</sup> randomized to receive antiretroviral therapy (ART) immediately versus delaying initiation of ART. Key updates related to these studies and other significant changes are highlighted throughout the guidelines.

### Key Updates

The following guideline sections include key updates:

#### *Initiation of Antiretroviral Therapy (“When to Start”)*

Based on the START and TEMPRANO findings, the Panel on Antiretroviral Guidelines for Adults and Adolescents (the Panel) has increased the strength and evidence rating for the recommendation on initiating ART to **AI** for all HIV-infected patients, regardless of CD4 count. Revisions to this section focus on the data supporting ART for all patients.

Following are the updated recommendations in this section:

- ART is recommended for all HIV-infected individuals, regardless of CD4 cell count, to reduce the morbidity and mortality associated with HIV infection (**AI**).
- ART is also recommended for HIV-infected individuals to prevent HIV transmission (**AI**).
- When initiating ART, it is important to educate patients on the benefits and considerations regarding ART, and to address strategies to optimize adherence. On a case-by-case basis, ART may be deferred because of clinical and/or psychosocial factors, but therapy should be initiated as soon as possible.

#### *Acute and Recent (Early) HIV Infection*

The recommendation for initiation of ART in patients diagnosed with acute and recent infection has been strengthened. The changes are highlighted below:

##### Original Recommendation:

- “Antiretroviral therapy (ART) is recommended for all individuals with HIV-1 infection **and should be offered to those with early HIV-1 infection (BII).**”

##### Updated Recommendation:

- “Antiretroviral therapy (ART) is recommended for all individuals with HIV-1 infection (**AI**) **including those with early HIV-1 infection.**”

#### *HIV-Infected Adolescents and Young Adults*

Following are two key updates to this section:

- The Panel noted that although the START and TEMPRANO study populations did not include adolescents, the recommendation to treat all HIV patients has been extrapolated to adolescents based on the expectation that they will derive benefits from early ART similar to those observed in adults.

- Recommendation that ART initiation in post-pubertal adolescents (sexual maturity rating [SMR] IV and V) be guided by the Adult and Adolescents Guidelines and therapy initiation in pre-pubertal adolescents (SMR I-III) by the Pediatric Guidelines.

### ***HIV and the Older Patient***

The updated section is focused on the current recommendation to treat all patients regardless of CD4 count. The section emphasizes that ART is especially important for older patients because they have a greater risk of serious non-AIDS complications and potentially a blunted immunologic response to ART.

### ***What to Start: Initial Combination Regimens for the Antiretroviral-Naive Patient***

The list of Recommended regimens for initial ART has been expanded to include elvitegravir/cobicistat/tenofovir alafenamide/emtricitabine for patients with estimated creatinine clearance  $\geq 30$  mL/min (**AI**).

More updates to the What to Start section will be forthcoming in the next revision of these Guidelines (anticipated in May or June 2016), including additional discussion of the newest recommended regimen.

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# HHS Panel on Antiretroviral Guidelines for Adults and Adolescents

## Panel Roster (Last updated January 28, 2016; last reviewed January 28, 2016)

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*These Guidelines were developed by the Department of Health and Human Services (HHS) Panel on Antiretroviral Guidelines for Adults and Adolescents (a Working Group of the Office of AIDS Research Advisory Council).*

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**Key to Abbreviations:** C = Co-Chair; DSMB = Data Safety Monitoring Board; ES = Executive Secretary; M = Member; N/A = Not Applicable

## Introduction (Last updated January 28, 2016; last reviewed January 28, 2016)

Antiretroviral therapy (ART) for the treatment of HIV infection has improved steadily since the advent of potent combination therapy in 1996. ART has dramatically reduced HIV-associated morbidity and mortality and has transformed HIV infection into a manageable chronic condition. In addition, ART is highly effective at preventing HIV transmission.<sup>1</sup> However, fewer than one-third of HIV-infected individuals in the United States have suppressed viral loads,<sup>2</sup> mostly resulting from undiagnosed HIV infection and failure to link or retain diagnosed patients in care.

The Department of Health and Human Services (HHS) Panel on Antiretroviral Guidelines for Adults and Adolescents (the Panel) is a working group of the Office of AIDS Research Advisory Council (OARAC). The primary goal of the Panel is to provide HIV care practitioners with recommendations based on current knowledge of antiretroviral drugs (ARV) used to treat adults and adolescents with HIV infection in the United States. The Panel reviews new evidence and updates recommendations when needed. These guidelines include recommendations on baseline laboratory evaluations, treatment goals, **benefits of ART and considerations when initiating therapy**, choice of the initial regimen for ART-naïve patients, ARV drugs or combinations to avoid, management of treatment failure, management of adverse effects and drug interactions, and special ART-related considerations in specific patient populations. **This Panel works closely with the HHS Panel on Antiretroviral Therapy and Medical Management of HIV-Infected Children to provide recommendations for adolescents at different stages of growth and development. Recommendations for ART regimens in these guidelines are most appropriate for post-pubertal adolescents (i.e., sexual maturity rating [SMR] stages IV and V). Clinicians should follow recommendations in the Pediatric Guidelines when initiating ART in adolescents at SMR stage III or lower.**<sup>3</sup> For recommendations related to pre- (PrEP) and post- (PEP) HIV exposure prophylaxis for HIV uninfected persons, clinicians should consult recommendations from the Centers for Disease Control and Prevention (CDC).<sup>4</sup>

These guidelines represent current knowledge regarding the use of ARVs. Because the science of HIV evolves rapidly, the availability of new agents and new clinical data may change therapeutic options and preferences. Information included in these guidelines may not always be consistent with approved labeling for the particular drugs or indications, and the use of the terms “safe” and “effective” may not be synonymous with the Food and Drug Administration (FDA)-defined legal standards for drug approval. The Panel frequently updates the guidelines (current and archived versions of the guidelines are available on the *AIDSinfo* website at <http://www.aidsinfo.nih.gov>). However, the guidelines cannot always be updated apace with the rapid evolution of new data and cannot offer guidance on care for all patients. Patient management decisions should be based on clinical judgement and attention to unique patient circumstances.

The Panel recognizes the importance of clinical research in generating evidence to address unanswered questions related to the optimal safety and efficacy of ART, and encourages both the development of protocols and patient participation in well-designed, Institutional Review Board (IRB)-approved clinical trials.

## Guidelines Development Process

**Table 1. Outline of the Guidelines Development Process**

Topic	Comment
<b>Goal of the guidelines</b>	Provide guidance to HIV care practitioners on the optimal use of antiretroviral agents (ARVs) for the treatment of HIV infection in adults and adolescents in the United States.
<b>Panel members</b>	The Panel is composed of approximately 45 voting members who have expertise in HIV care and research, and includes at least one representative from each of the following U.S. Department of Health and Human Services (HHS) agencies: Centers for Disease Control and Prevention (CDC), Food and Drug Administration (FDA), Health Resource and Services Administration (HRSA), and National Institutes of Health (NIH). Approximately two-thirds of the Panel members are non-governmental scientific members. The Panel also includes four to five community members with knowledge in HIV treatment and care. The U.S. government representatives are appointed by their respective agencies; other Panel members are selected after an open announcement to call for nominations. Each member serves on the Panel for a 4 year term with an option for reappointment for an additional term. See the <a href="#">Panel Roster</a> for a list of current Panel members.
<b>Financial disclosure</b>	All members of the Panel submit a written financial disclosure annually, reporting any association with manufacturers of ARV drugs or diagnostics used for management of HIV infections. A <a href="#">list of the latest disclosures</a> is available on the AIDSinfo website ( <a href="http://aidsinfo.nih.gov/contentfiles/AA_FinancialDisclosures.pdf">http://aidsinfo.nih.gov/contentfiles/AA_FinancialDisclosures.pdf</a> ).
<b>Users of the guidelines</b>	HIV treatment providers
<b>Developer</b>	Panel on Antiretroviral Guidelines for Adults and Adolescents—a working group of the Office of AIDS Research Advisory Council (OARAC)
<b>Funding source</b>	Office of AIDS Research, NIH
<b>Evidence collection</b>	The recommendations in the guidelines are based on studies published in peer reviewed journals. On some occasions, particularly when new information may affect patient safety, unpublished data presented at major conferences or prepared by the FDA and/or manufacturers as warnings to the public may be used as evidence to revise the guidelines.
<b>Recommendation grading</b>	As described in <a href="#">Table 2</a>
<b>Method of synthesizing data</b>	Each section of the guidelines is assigned to a working group of Panel members with expertise in the section's area of interest. The working groups synthesize available data and propose recommendations to the Panel. The Panel discusses all proposals during monthly teleconferences. Recommendations endorsed by the Panel are included in the guidelines.
<b>Other guidelines</b>	These guidelines focus on ART use for HIV-infected adults and adolescents. For more detailed discussion on the use of antiretroviral therapy (ART) for children <b>and pre-pubertal adolescents (SMR Stages I – III)</b> , clinicians should refer to the <a href="#">Pediatric Antiretroviral Guidelines</a> .  These guidelines also include a brief discussion on the management of women of reproductive age and pregnant women.
<b>Update plan</b>	The Panel meets monthly by teleconference to review data that may warrant modification of the guidelines. Updates may be prompted by new drug approvals (or new indications, dosing formulations, or frequency of dosing), new safety or efficacy data, or other information that may have an impact on the clinical care of patients. In the event of new data of clinical importance, the Panel may post an interim announcement with recommendations on the AIDSinfo website until the guidelines can be updated with the appropriate changes. Updated guidelines are available on the AIDSinfo website ( <a href="http://www.aidsinfo.nih.gov">http://www.aidsinfo.nih.gov</a> ).
<b>Public comments</b>	A 2-week public comment period follows release of the updated guidelines on the AIDSinfo website. The Panel reviews comments received to determine whether additional revisions to the guidelines are indicated. The public may also submit comments to the Panel at any time at <a href="mailto:contactus@aidsinfo.nih.gov">contactus@aidsinfo.nih.gov</a> .



## Basis for Recommendations

Recommendations in these guidelines are based upon scientific evidence and expert opinion. Each recommended statement includes a letter (A, B, or C) that represents the strength of the recommendation and a Roman numeral (I, II, or III) that represents the quality of the evidence that supports the recommendation (see Table 2).

**Table 2. Rating Scheme for Recommendations**

Strength of Recommendation	Quality of Evidence for Recommendation
<b>A:</b> Strong recommendation for the statement	<b>I:</b> One or more randomized trials with clinical outcomes and/or validated laboratory endpoints
<b>B:</b> Moderate recommendation for the statement	<b>II:</b> One or more well-designed, non-randomized trials or observational cohort studies with long-term clinical outcomes
<b>C:</b> Optional recommendation for the statement	<b>III:</b> Expert opinion

## HIV Expertise in Clinical Care

Several studies have demonstrated that overall outcomes in HIV-infected patients are better when care is delivered by clinicians with HIV expertise (e.g., care for a larger panel of patients),<sup>5-9</sup> reflecting the complexity of HIV infection and its treatment. Appropriate training, continuing education, and clinical experience are all components of optimal care. Providers who do not have this requisite training and experience should consult HIV experts when needed.

## References

1. Cohen MS, Chen YQ, McCauley M, et al. Prevention of HIV-1 infection with early antiretroviral therapy. *N Engl J Med*. Aug 11 2011;365(6):493-505. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=21767103](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=21767103).
2. Centers for Disease Control and Prevention. HIV in the United States: the stages of care—CDC Fact Sheet. 2014. Available at <http://www.cdc.gov/nchhstp/newsroom/docs/HIV-Stages-of-Care-Factsheet-508.pdf>. Accessed December 21, 2015.
3. Panel on Antiretroviral Therapy and Medical Management of HIV-Infected Children. Guidelines for the use of antiretroviral agents in pediatric HIV infection. 2014. Available at <http://aidsinfo.nih.gov/contentfiles/lvguidelines/pediatricguidelines.pdf>. Accessed January 12, 2016.
4. Centers for Disease Control and Prevention, U.S. Public Health Service. Pre-exposure prophylaxis for the prevention of HIV infection in the United States—2014: a clinical practice guideline. 2014. Available at <http://www.cdc.gov/hiv/pdf/PrEPguidelines2014.pdf>. Accessed November 2, 2015.
5. Kitahata MM, Van Rompaey SE, Shields AW. Physician experience in the care of HIV-infected persons is associated with earlier adoption of new antiretroviral therapy. *J Acquir Immune Defic Syndr*. Jun 1 2000;24(2):106-114. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=10935685](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=10935685).
6. Landon BE, Wilson IB, McInnes K, et al. Physician specialization and the quality of care for human immunodeficiency virus infection. *Arch Intern Med*. May 23 2005;165(10):1133-1139. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=15911726](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15911726).
7. Kitahata MM, Van Rompaey SE, Dillingham PW, et al. Primary care delivery is associated with greater physician experience and improved survival among persons with AIDS. *J Gen Intern Med*. Feb 2003;18(2):95-103. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=12542583](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=12542583).
8. Delgado J, Heath KV, Yip B, et al. Highly active antiretroviral therapy: physician experience and enhanced adherence to prescription refill. *Antivir Ther*. Oct 2003;8(5):471-478. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=14640395](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=14640395).



9. O'Neill M, Karelis GD, Feller DJ, et al. The HIV Workforce in New York State: Does Patient Volume Correlate with Quality? *Clin Infect Dis*. Dec 15 2015;61(12):1871-1877. Available at <http://www.ncbi.nlm.nih.gov/pubmed/26423383>.

## Baseline Evaluation (Last updated May 1, 2014; last reviewed May 1, 2014)

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Every HIV-infected patient entering into care should have a complete medical history, physical examination, and laboratory evaluation and should be counseled regarding the implications of HIV infection. The goals of the initial evaluation are to confirm the diagnosis of HIV infection, obtain appropriate baseline historical and laboratory data, ensure patient understanding about HIV infection and its transmission, and to initiate care as recommended in HIV primary care guidelines<sup>1</sup> and guidelines for prevention and treatment of HIV-associated opportunistic infections.<sup>2</sup> The initial evaluation also should include introductory discussion on the benefits of antiretroviral therapy (ART) for the patient's health and to prevent HIV transmission. Baseline information then can be used to define management goals and plans. In the case of previously treated patients who present for an initial evaluation with a new health care provider, it is critical to obtain a complete antiretroviral (ARV) history (including drug-resistance testing results, if available), preferably through the review of past medical records. Newly diagnosed patients should also be asked about any prior use of ARV agents for prevention of HIV infection.

The following laboratory tests performed during initial patient visits can be used to stage HIV disease and to assist in the selection of ARV drug regimens:

- HIV antibody testing (if prior documentation is not available or if HIV RNA is below the assay's limit of detection) **(AI)**;
- CD4 T-cell count (CD4 count) **(AI)**;
- Plasma HIV RNA (viral load) **(AI)**;
- Complete blood count, chemistry profile, transaminase levels, blood urea nitrogen (BUN), and creatinine, urinalysis, and serologies for hepatitis A, B, and C viruses **(AIII)**;
- Fasting blood glucose and serum lipids **(AIII)**; and
- Genotypic resistance testing at entry into care, regardless of whether ART will be initiated immediately **(AII)**. For patients who have HIV RNA levels <500 to 1,000 copies/mL, viral amplification for resistance testing may not always be successful **(BII)**.

In addition, other tests (including screening tests for sexually transmitted infections and tests for determining the risk of opportunistic infections and need for prophylaxis) should be performed as recommended in HIV primary care and opportunistic infections guidelines.<sup>1, 2</sup>

Patients living with HIV infection often must cope with many social, psychiatric, and medical issues that are best addressed through a patient-centered, multi-disciplinary approach to the disease. The baseline evaluation should include an evaluation of the patient's readiness for ART, including an assessment of high-risk behaviors, substance abuse, social support, mental illness, comorbidities, economic factors (e.g., unstable housing), medical insurance status and adequacy of coverage, and other factors that are known to impair adherence to ART and increase the risk of HIV transmission. Once evaluated, these factors should be managed accordingly. The baseline evaluation should also include a discussion of risk reduction and disclosure to sexual and/or needle sharing partners, especially with untreated patients who are still at high risk of HIV transmission.

Education about HIV risk behaviors and effective strategies to prevent HIV transmission should be provided at each patient visit (see [Preventing Secondary Transmission of HIV](#)).

## References

1. Aberg JA, Gallant JE, Ghanem KG, Emmanuel P, Zingman BS, Horberg MA. Primary care guidelines for the management of persons infected with HIV: 2013 update by the HIV medicine association of the Infectious Diseases Society of America. *Clin Infect Dis*. 2014;58(1):e1-34. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24235263>.

2. Panel on Opportunistic Infections in HIV-Infected Adults and Adolescents. Guidelines for the prevention and treatment of opportunistic infections in HIV-infected adults and adolescents: recommendations from the Centers for Disease Control and Prevention, the National Institutes of Health, and the HIV Medicine Association of the Infectious Diseases Society of America. Available at [http://aidsinfo.nih.gov/contentfiles/lvguidelines/adult\\_oi.pdf](http://aidsinfo.nih.gov/contentfiles/lvguidelines/adult_oi.pdf). Accessed January 6, 2014.

## Laboratory Testing

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### Laboratory Testing for Initial Assessment and Monitoring of HIV-Infected Patients on Antiretroviral Therapy (Last updated January 28, 2016; last reviewed January 28, 2016)

A number of laboratory tests are important for initial evaluation of HIV-infected patients upon entry into care, and before and after initiation or modification of therapy to assess the virologic and immunologic efficacy of antiretroviral therapy (ART) and to monitor for laboratory abnormalities that may be associated with antiretroviral (ARV) drugs. [Table 3](#) outlines the Panel on Antiretroviral Guidelines for Adults and Adolescents (the Panel)'s recommendations on the frequency of testing. As noted in the table, some tests may be repeated more frequently if clinically indicated.

Two surrogate markers are used routinely to assess immune function and level of HIV viremia: CD4 T lymphocyte cell count and plasma HIV RNA (viral load), respectively. Resistance testing should be used to guide selection of an antiretroviral regimen. A viral tropism assay should be performed before initiation of a CCR5 antagonist or at the time of virologic failure that occurs while a patient is receiving a CCR5 antagonist. HLA-B\*5701 testing should be performed before initiation of abacavir. **As the treatment of hepatitis B or hepatitis C virus co-infection may impact the choice of ART, patients should be screened for these co-infections before initiating ART.** The rationale for and utility of these laboratory tests are discussed in the corresponding sections of the guidelines.

**Table 3. Laboratory Monitoring Schedule for HIV-Infected Patients Before and After Initiation of Antiretroviral Therapy<sup>a</sup>** (page 1 of 2)

Laboratory Test	Timepoint/Frequency of Testing								
	Entry into Care	ART Initiation <sup>b</sup> or Modification	2 to 8 Weeks After ART Initiation or Modification	Every 3 to 6 Months	Every 6 Months	Every 12 Months	Treatment Failure	Clinically Indicated	If ART Initiation is Delayed <sup>c</sup>
HIV Serology	√ If HIV diagnosis has not been confirmed								
CD4 Count	√	√		√  During first 2 years of ART or if viremia develops while patient on ART or CD4 count <300 cells/mm <sup>3</sup>		√  <u>After 2 years on ART with consistently suppressed viral load:</u> CD4 Count 300–500 cells/mm <sup>3</sup> : • Every 12 months  CD4 Count >500 cells/mm <sup>3</sup> : • CD4 monitoring is optional	√	√	√  Every 3–6 months
HIV Viral Load	√	√	√ <sup>d</sup>	√ <sup>e</sup>	√ <sup>e</sup>		√	√	Repeat testing is optional
Resistance Testing	√	√ <sup>f</sup>					√	√	√ <sup>f</sup>
HLA-B*5701 Testing		√  If considering ABC							
Tropism Testing		√  If considering a CCR5 antagonist					√  If considering a CCR5 antagonist or for failure of CCR5 antagonist-based regimen	√	

**Table 3. Laboratory Monitoring Schedule for HIV-Infected Patients Before and After Initiation of Antiretroviral Therapy<sup>a</sup>** (page 2 of 2)

Laboratory Test	Timepoint/Frequency of Testing								
	Entry into Care	ART Initiation <sup>b</sup> or Modification	2 to 8 Weeks After ART Initiation or Modification	Every 3 to 6 Months	Every 6 Months	Every 12 Months	Treatment Failure	Clinically Indicated	If ART Initiation is Delayed <sup>c</sup>
<b>Hepatitis B Serology<sup>g,h</sup></b>	√	√ May repeat if patient non-immune and not chronically infected with HBV <sup>h</sup>				√ May repeat if patient non-immune and not chronically infected with HBV <sup>h</sup>		√	
<b>Hepatitis C Antibody Test</b> (if positive, confirm with HCV RNA test)	√	√ May repeat for at-risk patients if negative result at baseline				√ May repeat for at-risk patients if negative result at baseline		√	
<b>Basic Chemistry<sup>ij</sup></b>	√	√	√	√				√	√ Every 6-12 months
<b>ALT, AST, T. bilirubin</b>	√	√	√	√				√	√ Every 6-12 months
<b>CBC with Differential</b>	√	√		√ (if CD4 testing is done)	√			√	√ Every 3-6 months
<b>Fasting Lipid Profile<sup>k</sup></b>	√	√			√ If abnormal at last measurement	√ If abnormal at last measurement		√	√ If normal at baseline, annually
<b>Fasting Glucose or Hemoglobin A1C</b>	√	√		√ If abnormal at last measurement		√ If abnormal at last measurement		√	√ If normal at baseline, annually
<b>Urinalysis<sup>j</sup></b>	√	√			√ If on TDF <sup>i</sup>	√		√	√ If normal at baseline, annually
<b>Pregnancy Test</b>		√ In women with child-bearing potential						√	

<sup>a</sup> This table pertains to laboratory tests done to select an ARV regimen and monitor for treatment responses or ART toxicities. Please refer to the HIV Primary Care guidelines for guidance on other laboratory tests generally recommended for primary health care maintenance of HIV patients.<sup>1</sup>

<sup>b</sup> If ART initiation occurs soon after HIV diagnosis and entry into care, repeat baseline laboratory testing is not necessary.

<sup>c</sup> ART is indicated for all HIV-infected individuals and should be started as soon as possible. However, if ART initiation is delayed, patients should be retained in care, with periodic monitoring as noted above.

<sup>d</sup> If HIV RNA is detectable at 2 to 8 weeks, repeat every 4 to 8 weeks until viral load is suppressed to <200 copies/mL, and thereafter, every 3 to 6 months.

<sup>e</sup> In patients on ART, viral load typically is measured every 3 to 4 months. However, for adherent patients with consistently suppressed viral load and stable immunologic status for more than 2 years, monitoring can be extended to 6 month intervals.

<sup>f</sup> In ART-naïve patients, if resistance testing was performed at entry into care, **but ART is not started immediately**, repeat testing before initiation of ART is optional. In virologically suppressed patients who are switching therapy because of toxicity or for convenience, viral amplification will not be possible; therefore, resistance testing should not be performed. Results from prior resistance testing can be helpful in constructing a new regimen.

<sup>g</sup> If HBsAg is positive, TDF plus either FTC or 3TC should be used as part of the ARV regimen to treat both HBV and HIV infections.

**Preliminary data from clinical trials have demonstrated activity of TAF against HBV. Final results from ongoing clinical trials will help to define the role of TAF in the treatment of HBV/HIV co-infection.**

<sup>h</sup> If HBsAg, and HBsAb, and anti-HBc are negative, hepatitis B vaccine series should be administered. Non-HBV immune individuals need evaluation for chronic infection and vaccination if not infected. Refer to HIV Primary Care **and Opportunistic Infections** guidelines for more detailed recommendations.<sup>1,2</sup>

<sup>i</sup> Serum Na, K, HCO<sub>3</sub>, Cl, BUN, creatinine, glucose (preferably fasting). Some experts suggest monitoring the phosphorus levels of patients on TDF. Determination of renal function should include **monitoring of creatinine-based estimated glomerular filtration rate**.<sup>3</sup>

<sup>j</sup> For patients with renal disease, consult the Guidelines for the Management of Chronic Kidney Disease in HIV-Infected Patients: Recommendations of the HIV Medicine Association of the Infectious Diseases Society of America for patient management recommendations.<sup>3</sup> More frequent monitoring may be indicated for patients with evidence of kidney disease (e.g., proteinuria, decreased glomerular dysfunction) or increased risk of renal insufficiency (e.g., patients with diabetes, hypertension).

<sup>k</sup> **Consult the National Lipid Association's recommendations for management of patients with dyslipidemia.**<sup>4</sup>

**Key to Acronyms:** 3TC = lamivudine; ABC = abacavir; ALT = alanine aminotransferase; ART = antiretroviral therapy; AST = aspartate aminotransferase; CBC = complete blood count; CrCl = creatinine clearance; EFV = efavirenz; FTC = emtricitabine; HBsAb = hepatitis B surface antibody; HBsAg = hepatitis B surface antigen; HBV = hepatitis B virus; **TAF = tenofovir alafenamide**; TDF = tenofovir disoproxil fumarate

## References

1. Aberg JA, Gallant JE, Ghanem KG, Emmanuel P, Zingman BS, Horberg MA. Primary care guidelines for the management of persons infected with HIV: 2013 update by the HIV medicine association of the Infectious Diseases Society of America. *Clin Infect Dis*. Jan 2014;58(1):e1-34. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24235263>.
2. Panel on Opportunistic Infections in HIV-Infected Adults and Adolescents. Guidelines for the prevention and treatment of opportunistic infections in HIV-infected adults and adolescents: recommendations from the Centers for Disease Control and Prevention, the National Institutes of Health, and the HIV Medicine Association of the Infectious Diseases Society of America. Available at [http://aidsinfo.nih.gov/contentfiles/lvguidelines/adult\\_oi.pdf](http://aidsinfo.nih.gov/contentfiles/lvguidelines/adult_oi.pdf). Accessed January 6, 2016.
3. Lucas GM, Ross MJ, Stock PG, et al. Clinical practice guideline for the management of chronic kidney disease in patients infected with HIV: 2014 update by the HIV Medicine Association of the Infectious Diseases Society of America. *Clin Infect Dis*. Nov 1 2014;59(9):e96-138. Available at <http://www.ncbi.nlm.nih.gov/pubmed/25234519>.
4. Jacobson TA, Ito MK, Maki KC, et al. National lipid association recommendations for patient-centered management of dyslipidemia: part 1--full report. *J Clin Lipidol*. Mar-Apr 2015;9(2):129-169. Available at <http://www.ncbi.nlm.nih.gov/pubmed/25911072>.

## Plasma HIV-1 RNA (Viral Load) and CD4 Count Monitoring (Last updated May 1, 2014; last reviewed May 1, 2014)

HIV RNA (viral load) and CD4 T lymphocyte (CD4) cell count are the two surrogate markers of antiretroviral treatment (ART) responses and HIV disease progression that have been used for decades to manage and monitor HIV infection.

Viral load is a marker of response to ART. A patient's pre-ART viral load level and the magnitude of viral load decline after initiation of ART provide prognostic information about the probability of disease progression.<sup>1</sup> The key goal of ART is to achieve and maintain durable viral suppression. Thus, the most important use of the viral load is to monitor the effectiveness of therapy **after** initiation of ART.

Measurement of CD4 count is particularly useful **before** initiation of ART. The CD4 cell count provides information on the overall immune function of an HIV-infected patient. The measurement is critical in establishing thresholds for the initiation and discontinuation of opportunistic infection (OI) prophylaxis and in assessing the urgency to initiate ART.

The management of HIV-infected patients has changed substantially with the availability of newer, more potent, and less toxic antiretroviral (ARV) agents. In the United States, ART is now recommended for all HIV-infected patients regardless of their viral load or CD4 count. In the past, clinical practice, which was supported by treatment guidelines, was generally to monitor both CD4 cell count and viral load concurrently. However, because most HIV-infected patients in care now receive ART, the rationale for frequent CD4 monitoring is weaker. The roles and usefulness of these two tests in clinical practice are discussed in the following sections.

### ***Plasma HIV-1 RNA (Viral Load) Monitoring***

Viral load is the most important indicator of initial and sustained response to ART (**AI**) and should be measured in all HIV-infected patients at entry into care (**AIII**), at initiation of therapy (**AIII**), and on a regular basis thereafter. For those patients who choose to delay therapy, repeat viral load testing while not on ART is optional (**CIII**). Pre-treatment viral load level is also an important factor in the selection of an initial ARV regimen because several currently approved ARV drugs or regimens have been associated with poorer responses in patients with high baseline viral load (see [What to Start](#)). Commercially available HIV-1 RNA assays do not detect HIV-2 viral load. For further discussion on HIV-2 RNA monitoring in patients with HIV-1/HIV-2 co-infection or HIV-2 mono-infection, see [HIV-2 Infection](#).

Several systematic reviews of data from clinical trials involving thousands of participants have established that decreases in viral load following initiation of ART are associated with reduced risk of progression to AIDS or death.<sup>1-3</sup> Thus, viral load testing is an established surrogate marker for treatment response.<sup>4</sup> The minimal change in viral load considered to be statistically significant (2 standard deviations) is a three-fold change (equivalent to a 0.5 log<sub>10</sub> copies/mL change). Optimal viral suppression is defined generally as a viral load persistently below the level of detection (HIV RNA <20 to 75 copies/mL, depending on the assay used). However, isolated blips (viral loads transiently detectable at low levels, typically HIV RNA <400 copies/mL) are not uncommon in successfully treated patients and are not predictive of virologic failure.<sup>5</sup> Furthermore, the data on the association between persistently low level but quantifiable viremia (HIV RNA <200 copies/mL) and virologic failure is conflicting. One recent study showed an increased risk of subsequent failure at this level of viremia; however, the association was not observed in other studies.<sup>6-9</sup> These guidelines and the AIDS Clinical Trials Group (ACTG) now define virologic failure as a confirmed viral load >200 copies/mL—a threshold that eliminates most cases of apparent viremia caused by viral load blips or assay variability<sup>10</sup> (see [Virologic Failure and Suboptimal Immunologic Response](#)).

Individuals who are adherent to their ARV regimens and do not harbor resistance mutations to the component drugs can generally achieve viral suppression 8 to 24 weeks after ART initiation; rarely, in some patients it



may take longer. Recommendations on the frequency of viral load monitoring are summarized below:

- **After initiation of ART or modification of therapy because of virologic failure.** Plasma viral load should be measured before initiation of ART and within 2 to 4 weeks but no later than 8 weeks after treatment initiation or modification (**AIII**). The purpose of the measurements is to confirm an adequate initial virologic response to ART, indicating appropriate regimen selection and patient adherence to therapy. Repeat viral load measurement should be performed at 4- to 8-week intervals until the level falls below the assay's limit of detection (**BIII**).
- **In virologically suppressed patients in whom ART was modified because of drug toxicity or for regimen simplification.** Viral load measurement should be performed within 4 to 8 weeks after changing therapy (**AIII**). The purpose of viral load monitoring at this point is to confirm the effectiveness of the new regimen.
- **In patients on a stable, suppressive ARV regimen.** Viral load should be repeated every 3 to 4 months (**AIII**) or as clinically indicated to confirm continuous viral suppression. Clinicians may extend the interval to 6 months for adherent patients whose viral load has been suppressed for more than 2 years and whose clinical and immunologic status is stable (**AIII**).
- **In patients with suboptimal response.** The frequency of viral load monitoring will depend on clinical circumstances, such as adherence and availability of further treatment options. In addition to viral load monitoring, a number of additional factors, such as patient adherence to prescribed medications, suboptimal drug exposure, or drug interactions, should be assessed. Patients who fail to achieve viral suppression should undergo resistance testing to aid in the selection of an alternative regimen (see [Drug-Resistance Testing](#) and [Virologic Failure and Suboptimal Immunologic Response](#) sections).

## ***CD4 Count Monitoring***

The CD4 count is the most important laboratory indicator of immune function in HIV-infected patients. It is also the strongest predictor of subsequent disease progression and survival according to findings from clinical trials and cohort studies.<sup>11,12</sup> CD4 counts are highly variable; a significant change (2 standard deviations) between 2 tests is approximately a 30% change in the absolute count, or an increase or decrease in CD4 percentage by 3 percentage points. Monitoring of lymphocyte subsets other than CD4 (e.g., CD8, CD19) has not proven clinically useful, is more expensive, and is **not routinely recommended** (**BIII**).

### **Use of CD4 Count for Initial Assessment**

CD4 count should be measured in all patients at entry into care (**AI**). It is the key factor in determining the need to initiate OI prophylaxis (see the [Adult Opportunistic Infection Guidelines](#))<sup>13</sup> and the urgency to initiate ART (**AI**) (see the [Initiating Antiretroviral Therapy in Antiretroviral-Naïve Patients](#) section of these guidelines). Although most OIs occur in patients with CD4 counts <200 cells/mm<sup>3</sup>, some OIs can occur in patients with higher CD4 counts.<sup>14</sup>

### **Use of CD4 Count for Monitoring Therapeutic Response**

The CD4 count is used to assess a patient's immunologic response to ART. It is also used to determine whether prophylaxis for OIs can be discontinued (see the [Adult Opportunistic Infection Guidelines](#))<sup>13</sup>. For most patients on therapy, an adequate response is defined as an increase in CD4 count in the range of 50 to 150 cells/mm<sup>3</sup> during the first year of ART, generally with an accelerated response in the first 3 months of treatment. Subsequent increases average approximately 50 to 100 cells/mm<sup>3</sup> per year until a steady state level is reached.<sup>15</sup> Patients who initiate therapy with a low CD4 count<sup>16</sup> or at an older age<sup>17</sup> may have a blunted increase in their counts despite virologic suppression.

## Frequency of CD4 Count Monitoring

ART is now recommended for all HIV-infected patients. In patients who remain untreated for whatever reason, CD4 counts should be monitored every 3 to 6 months to assess the urgency of ART initiation and the need for OI prophylaxis (**AIII**).

A repeat CD4 count 3 months after ART initiation will provide information regarding the magnitude of immune reconstitution (**AIII**). This repeat measurement is most important in patients who initiate ART with more advanced disease and require OI prophylaxis or treatment. In these patients, the magnitude and duration of CD4 count increase can be used to determine whether to discontinue OI prophylaxis and/or treatment as recommended in the guidelines for treatment and prophylaxis of opportunistic infections.<sup>13</sup> In this setting, and in the first 2 years following ART initiation, CD4 count can be monitored at 3- to 6-month intervals (**BII**).

The CD4 count response to ART varies widely, but a poor CD4 response in a patient with viral suppression is rarely an indication for modifying an ARV regimen. In patients with consistently suppressed viral loads who have already experienced ART-related immune reconstitution, the CD4 count provides limited information. Frequent testing is unnecessary because the results rarely lead to a change in clinical management. One retrospective study found that declines in CD4 count to  $<200$  cells/mm<sup>3</sup> are rare in patients with viral suppression and CD4 counts  $>300$  cells/mm<sup>3</sup>.<sup>18</sup> Similarly, the ARTEMIS trial found that CD4 monitoring had no clinical benefit in patients who had suppressed viral loads and CD4 counts  $>200$  cells/mm<sup>3</sup> after 48 weeks of therapy.<sup>19</sup> Furthermore, the risk of *Pneumocystis jirovecii* pneumonia is extremely low in patients on suppressive ART who have CD4 counts between 100 and 200 cells/mm<sup>3</sup>.<sup>20</sup> Although uncommon, CD4 count declines can occur in a small percentage of virologically suppressed patients and may be associated with adverse clinical outcomes such as cardiovascular disease, malignancy, and death.<sup>21</sup> An analysis of costs associated with CD4 monitoring in the United States estimated that reducing CD4 monitoring in treated patients from every 6 months to every 12 months could result in annual savings of approximately \$10 million.<sup>22</sup>

For the patient on a suppressive regimen whose CD4 count has consistently ranged between 300 and 500 cells/mm<sup>3</sup> for at least 2 years, the Panel recommends CD4 monitoring on an annual basis (**BII**). Continued CD4 monitoring for virologically suppressed patients whose CD4 counts have been consistently  $>500$  cells/mm<sup>3</sup> for at least 2 years may be considered optional (**CIII**). The CD4 count should be monitored more frequently, as clinically indicated, when there are changes in a patient's clinical status that may decrease CD4 count and thus prompt OI prophylaxis. Examples of such changes include the appearance of new HIV-associated clinical symptoms or initiation of treatment known to reduce CD4 cell count (e.g., interferon, chronic corticosteroids, or anti-neoplastic agents) (**AIII**). In patients who fail to maintain viral suppression while on ART, the Panel recommends CD4 count monitoring every 3 to 6 months (**AIII**) (see [Virologic Failure and Suboptimal Immunologic Response](#) section).

## Factors that Affect Absolute CD4 Count

The absolute CD4 count is a calculated value based on the total white blood cell (WBC) count and the percentages of total and CD4+ T lymphocytes. This absolute number may fluctuate in individuals or may be influenced by factors that may affect the total WBC count and lymphocyte percentages, such as use of bone marrow-suppressive medications or the presence of acute infections. Splenectomy<sup>23,24</sup> or co-infection with human T-lymphotropic virus type I (HTLV-1)<sup>25</sup> may cause misleadingly elevated CD4 counts. Alpha-interferon may reduce the absolute CD4 count without changing the CD4 percentage.<sup>26</sup> In all these settings, CD4 percentage remains stable and may be a more appropriate parameter to assess a patient's immune function.

**Table 4. Recommendations on the Indications and Frequency of Viral Load and CD4 Count Monitoring<sup>a</sup>**

Clinical Scenario	Viral Load Monitoring	CD4 Count Monitoring
Before initiating ART	At entry into care <b>(AIII)</b>  If ART initiation is deferred, repeat before initiating ART <b>(AIII)</b> .  In patients not initiating ART, repeat testing is optional <b>(CIII)</b> .	At entry into care <b>(AI)</b>  If ART is deferred, every 3 to 6 months <b>(AIII)</b> . <sup>b</sup>
After initiating ART	Preferably within 2 to 4 weeks (and no later than 8 weeks) after initiation of ART <b>(AIII)</b> ; thereafter, every 4 to 8 weeks until viral load suppressed <b>(BIII)</b> .	3 months after initiation of ART <b>(AIII)</b>
After modifying ART because of drug toxicities or for regimen simplification in a patient with viral suppression	4 to 8 weeks after modification of ART to confirm effectiveness of new regimen <b>(AIII)</b> .	Monitor according to prior CD4 count and duration on ART, as outlined below.
After modifying ART because of virologic failure	Preferably within 2 to 4 weeks (and no later than 8 weeks) after modification <b>(AIII)</b> ; thereafter, every 4 to 8 weeks until viral load suppressed <b>(BIII)</b> . If viral suppression is not possible, repeat viral load every 3 months or more frequently if indicated <b>(AIII)</b> .	Every 3 to 6 months <b>(AI)</b>
During the first 2 years of ART	Every 3 to 4 months <b>(AIII)</b>	Every 3 to 6 months <sup>a</sup> <b>(BII)</b>
After 2 years of ART (VL consistently suppressed, CD4 consistently 300-500 cells/mm <sup>3</sup> )	Can extend to every 6 months for patients with consistent viral suppression for ≥2 years <b>(AIII)</b> .	Every 12 months <b>(BII)</b>
After 2 years of ART (VL consistently suppressed, CD4 consistently >500 cells/mm <sup>3</sup> )		Optional <b>(CIII)</b>
While on ART with detectable viremia (VL repeatedly >200 copies/mL)	Every 3 months <b>(AIII)</b> or more frequently if clinically indicated. (See <a href="#">Virologic Failure and Suboptimal Immunologic Response</a> section)	Every 3 to 6 months <b>(AIII)</b>
Change in clinical status (e.g., new HIV clinical symptom or initiation of interferon, chronic systemic corticosteroids, or antineoplastic therapy)	Every 3 months <b>(AIII)</b>	Perform CD4 count and repeat as clinically indicated <sup>c</sup> <b>(AIII)</b>

<sup>a</sup> Monitoring of lymphocyte subsets other than CD4 (e.g., CD8, CD19) has not proven clinically useful, adds to costs, and is not routinely recommended **(BIII)**.

<sup>b</sup> Some experts may repeat CD4 count every 3 months in patients with low baseline CD4 count (<200–300 cells/mm<sup>3</sup>) before ART but every 6 months in those who initiated ART at higher CD4 cell count (e.g., >300 cells/mm<sup>3</sup>).

<sup>c</sup> The following are examples of clinically indicated scenarios: changes in a patient's clinical status that may decrease CD4 count and thus prompt initiation of prophylaxis for opportunistic infections (OI), such as new HIV-associated symptoms, or initiation of treatment with medications which are known to reduce CD4 cell count.

## References

- Murray JS, Elashoff MR, Iacono-Connors LC, Cvetkovich TA, Struble KA. The use of plasma HIV RNA as a study endpoint in efficacy trials of antiretroviral drugs. *AIDS*. 1999;13(7):797-804. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=10357378](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=10357378).

2. Marschner IC, Collier AC, Coombs RW, et al. Use of changes in plasma levels of human immunodeficiency virus type 1 RNA to assess the clinical benefit of antiretroviral therapy. *J Infect Dis*. 1998;177(1):40-47. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=9419168](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=9419168).
3. Thiebaut R, Morlat P, Jacqmin-Gadda H, et al, with the Groupe d'Epidemiologie du SIDA en Aquitaine (GECSA). Clinical progression of HIV-1 infection according to the viral response during the first year of antiretroviral treatment. *AIDS*. 2000;14(8):971-978. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=10853978](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=10853978).
4. Human immunodeficiency virus type 1 RNA level and CD4 count as prognostic markers and surrogate end points: a meta-analysis. HIV Surrogate Marker Collaborative Group. *AIDS Res Hum Retroviruses*. 2000;16(12):1123-1133. Available at <http://www.ncbi.nlm.nih.gov/pubmed/10954887>.
5. Havlir DV, Bassett R, Levitan D, et al. Prevalence and predictive value of intermittent viremia with combination hiv therapy. *JAMA*. 2001;286(2):171-179. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=11448280](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11448280).
6. Damond F, Roquebert B, Benard A, et al. Human immunodeficiency virus type 1 (HIV-1) plasma load discrepancies between the Roche COBAS AMPLICOR HIV-1 MONITOR Version 1.5 and the Roche COBAS AmpliPrep/COBAS TaqMan HIV-1 assays. *J Clin Microbiol*. 2007;45(10):3436-3438. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17715371](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17715371).
7. Gatanaga H, Tsukada K, Honda H, et al. Detection of HIV type 1 load by the Roche Cobas TaqMan assay in patients with viral loads previously undetectable by the Roche Cobas Amplicor Monitor. *Clin Infect Dis*. 2009;48(2):260-262. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19113986](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19113986).
8. Willig JH, Nevin CR, Raper JL, et al. Cost ramifications of increased reporting of detectable plasma HIV-1 RNA levels by the Roche COBAS AmpliPrep/COBAS TaqMan HIV-1 version 1.0 viral load test. *J Acquir Immune Defic Syndr*. 2010;54(4):442-444. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=20611035](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20611035).
9. Laprise C, de Pokomandy A, Baril JG, Dufresne S, Trottier H. Virologic failure following persistent low-level viremia in a cohort of HIV-positive patients: results from 12 years of observation. *Clin Infect Dis*. 2013;57(10):1489-1496. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23946221>.
10. Ribaud H, Lennox J, Currier J, et al. Virologic failure endpoint definition in clinical trials: Is using HIV-1 RNA threshold <200 copies/mL better than <50 copies/mL? An analysis of ACTG studies. Paper presented at: 16th Conference on Retroviruses and Opportunistic Infection; 2009; Montreal, Canada.
11. Mellors JW, Munoz A, Giorgi JV, et al. Plasma viral load and CD4+ lymphocytes as prognostic markers of HIV-1 infection. *Ann Intern Med*. 1997;126(12):946-954. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=9182471](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=9182471).
12. Egger M, May M, Chene G, et al. Prognosis of HIV-1-infected patients starting highly active antiretroviral therapy: a collaborative analysis of prospective studies. *Lancet*. 2002;360(9327):119-129. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=12126821](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=12126821).
13. Panel on Opportunistic Infections in HIV-Infected Adults and Adolescents. Guidelines for the prevention and treatment of opportunistic infections in HIV-infected adults and adolescents: recommendations from the Centers for Disease Control and Prevention, the National Institutes of Health, and the HIV Medicine Association of the Infectious Diseases Society of America. Available at [http://aidsinfo.nih.gov/contentfiles/lvguidelines/adult\\_oi.pdf](http://aidsinfo.nih.gov/contentfiles/lvguidelines/adult_oi.pdf). Accessed January 6, 2014.
14. Mocroft A, Furrer HJ, Miro JM, et al. The incidence of AIDS-defining illnesses at a current CD4 count  $\geq$  200 cells/ $\mu$ L in the post-combination antiretroviral therapy era. *Clin Infect Dis*. 2013;57(7):1038-1047. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23921881>.
15. Kaufmann GR, Perrin L, Pantaleo G, et al. CD4 T-lymphocyte recovery in individuals with advanced HIV-1 infection receiving potent antiretroviral therapy for 4 years: the Swiss HIV Cohort Study. *Arch Intern Med*. 2003;163(18):2187-2195. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=14557216](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=14557216).
16. Moore RD, Keruly JC. CD4+ cell count 6 years after commencement of highly active antiretroviral therapy in persons with sustained virologic suppression. *Clin Infect Dis*. 2007;44(3):441-446. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17205456](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17205456).

17. Althoff KN, Justice AC, Gange SJ, et al. Virologic and immunologic response to HAART, by age and regimen class. *AIDS*. 2010;24(16):2469-2479. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=20829678](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20829678).
18. Gale HB, Gitterman SR, Hoffman HJ, et al. Is frequent CD4+ T-lymphocyte count monitoring necessary for persons with counts  $\geq 300$  cells/ $\mu$ L and HIV-1 suppression? *Clin Infect Dis*. 2013;56(9):1340-1343. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23315315>.
19. Girard PM, Nelson M, Mohammed P, Hill A, van Delft Y, Moecklinghoff C. Can we stop CD4+ testing in patients with HIV-1 RNA suppression on antiretroviral treatment? *AIDS*. 2013;27(17):2759-2763. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23842127>.
20. Costiniuk CT, Fergusson DA, Doucette S, Angel JB. Discontinuation of *Pneumocystis jirovecii* pneumonia prophylaxis with CD4 count  $< 200$  cells/ $\mu$ L and virologic suppression: a systematic review. *PLoS One*. 2011;6(12):e28570. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22194853>.
21. Helleberg M, Kronborg G, Larsen CS, et al. CD4 decline is associated with increased risk of cardiovascular disease, cancer, and death in virally suppressed patients with HIV. *Clin Infect Dis*. 2013;57(2):314-321. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23575194>.
22. Hyle EP, Sax PE, Walensky RP. Potential savings by reduced CD4 monitoring in stable patients with HIV receiving antiretroviral therapy. *JAMA Intern Med*. 2013;173(18):1746-1748. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23978894>.
23. Zurlo JJ, Wood L, Gaglione MM, Polis MA. Effect of splenectomy on T lymphocyte subsets in patients infected with the human immunodeficiency virus. *Clin Infect Dis*. 1995;20(4):768-771. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=7795071](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=7795071).
24. Bernard NF, Chernoff DN, Tsoukas CM. Effect of splenectomy on T-cell subsets and plasma HIV viral titers in HIV-infected patients. *J Hum Virol*. 1998;1(5):338-345. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=10195261](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=10195261).
25. Casseb J, Posada-Vergara MP, Montanheiro P, et al. T CD4+ cells count among patients co-infected with human immunodeficiency virus type 1 (HIV-1) and human T-cell leukemia virus type 1 (HTLV-1): high prevalence of tropical spastic paraparesis/HTLV-1-associated myelopathy (TSP/HAM). *Rev Inst Med Trop Sao Paulo*. 2007;49(4):231-233. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17823752](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17823752).
26. Berglund O, Engman K, Ehrnst A, et al. Combined treatment of symptomatic human immunodeficiency virus type 1 infection with native interferon-alpha and zidovudine. *J Infect Dis*. 1991;163(4):710-715. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=1672701](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=1672701).



## Drug-Resistance Testing (Last updated May 1, 2014; last reviewed May 1, 2014)

### Panel's Recommendations

- HIV drug-resistance testing is recommended in persons with HIV infection at entry into care regardless of whether antiretroviral therapy (ART) will be initiated immediately or deferred (**AII**). If therapy is deferred, repeat testing should be considered at the time of ART initiation (**CIII**).
- Genotypic testing is recommended as the preferred resistance testing to guide therapy in antiretroviral (ARV)-naïve patients (**AIII**).
- Standard genotypic drug-resistance testing in ARV-naïve persons involves testing for mutations in the reverse transcriptase (RT) and protease (PR) genes. If transmitted integrase strand transfer inhibitor (INSTI) resistance is a concern, providers may wish to supplement standard genotypic resistance testing with an INSTI genotype test (**CIII**).
- HIV drug-resistance testing should be performed to assist in the selection of active drugs when changing ARV regimens in persons with virologic failure and HIV RNA levels >1,000 copies/mL (**AI**). In persons with HIV RNA levels >500 but <1,000 copies/mL, testing may be unsuccessful but should still be considered (**BII**).
- Drug-resistance testing should also be performed when managing suboptimal viral load reduction (**AII**).
- In persons failing INSTI-based regimens, genotypic testing for INSTI resistance should be performed to determine whether to include a drug from this class in subsequent regimens (**AII**).
- Drug-resistance testing in the setting of virologic failure should be performed while the person is taking prescribed ARV drugs or, if not possible, within 4 weeks after discontinuing therapy (**AII**). If greater than 4 weeks has lapsed since the ARVs were discontinued, resistance testing may still provide useful information to guide therapy, recognizing that previously selected resistance mutations can be missed (**CIII**).
- Genotypic testing is recommended as the preferred resistance testing to guide therapy in patients with suboptimal virologic responses or virologic failure while on first or second regimens (**AII**).
- The addition of phenotypic to genotypic testing is generally preferred for persons with known or suspected complex drug-resistance mutation patterns, particularly to protease inhibitors (PIs) (**BIII**).
- Genotypic resistance testing is recommended for all pregnant women before initiation of ART (**AIII**) and for those entering pregnancy with detectable HIV RNA levels while on therapy (**AI**) (see the [Perinatal Treatment Guidelines](#) for more detailed discussion).

**Rating of Recommendations:** A = Strong; B = Moderate; C = Optional

**Rating of Evidence:** I = Data from randomized controlled trials; II = Data from well-designed nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion

### Genotypic and Phenotypic Resistance Assays

Genotypic and phenotypic resistance assays are used to assess viral strains and inform selection of treatment strategies. Standard assays provide information on resistance to nucleoside reverse transcriptase inhibitors (NRTIs), non-nucleoside reverse transcriptase inhibitors (NNRTIs), and protease inhibitors (PIs). Testing for integrase and fusion inhibitor resistance can also be ordered separately from several commercial laboratories. Co-receptor tropism assays should be performed whenever the use of a CCR5 antagonist is being considered. Phenotypic co-receptor tropism assays have been used in clinical practice. A genotypic assay to predict co-receptor use is now commercially available (see [Co-receptor Tropism Assays](#)).

### Genotypic Assays

Genotypic assays detect drug-resistance mutations present in relevant viral genes. Most genotypic assays involve sequencing of the RT and PR genes to detect mutations that are known to confer drug resistance. Genotypic assays that assess mutations in the integrase and gp41 (envelope) genes are also commercially available. Genotypic assays can be performed rapidly and results are available within 1 to 2 weeks of sample collection. Interpretation of test results requires knowledge of the mutations selected by different antiretroviral (ARV) drugs and of the potential for cross resistance to other drugs conferred by certain mutations. The International AIDS Society-USA (IAS-USA) maintains an updated list of significant resistance-associated mutations in the RT, PR, integrase, and envelope genes (see

[http://www.iasusa.org/resistance\\_mutations](http://www.iasusa.org/resistance_mutations)).<sup>1</sup> The Stanford University HIV Drug Resistance Database (<http://hivdb.stanford.edu>) also provides helpful guidance for interpreting genotypic resistance test results. Various tools to assist the provider in interpreting genotypic test results are now available.<sup>2-5</sup> Clinical trials have demonstrated that consultation with specialists in HIV drug resistance improves virologic outcomes.<sup>6</sup> Clinicians are thus encouraged to consult a specialist to facilitate interpretation of genotypic test results and design of an optimal new regimen.

### Phenotypic Assays

Phenotypic assays measure the ability of a virus to grow in different concentrations of ARV drugs. RT and PR gene sequences and, more recently, integrase and envelope sequences derived from patient plasma HIV RNA are inserted into the backbone of a laboratory clone of HIV or used to generate pseudotyped viruses that express the patient-derived HIV genes of interest. Replication of these viruses at different drug concentrations is monitored by expression of a reporter gene and is compared with replication of a reference HIV strain. The drug concentration that inhibits viral replication by 50% (i.e., the median inhibitory concentration [IC<sub>50</sub>]) is calculated, and the ratio of the IC<sub>50</sub> of test and reference viruses is reported as the fold increase in IC<sub>50</sub> (i.e., fold resistance).

Automated phenotypic assays that can produce results in 2 to 3 weeks are commercially available, but they cost more to perform than genotypic assays. In addition, interpretation of phenotypic assay results is complicated by incomplete information regarding the specific resistance level (i.e., fold increase in IC<sub>50</sub>) that is associated with drug failure, although clinically significant fold increase cutoffs are now available for some drugs.<sup>7-11</sup> Again, consultation with a specialist to interpret test results can be helpful.

Further limitations of both genotypic and phenotypic assays include lack of uniform quality assurance testing for all available assays, relatively high cost, and insensitivity to minor viral species. Despite being present, drug-resistant viruses that constitute less than 10% to 20% of the circulating virus population will probably not be detected by commercially available assays. This limitation is important because after drugs exerting selective pressure on drug-resistant populations are discontinued, a wild-type virus often re-emerges as the predominant population in the plasma. As a consequence, the proportion of virus with resistance mutations decreases to below the 10% to 20% threshold.<sup>12-14</sup> In the case of some drugs, this reversion to predominantly wild-type virus can occur in the first 4 to 6 weeks after the drugs are discontinued. Prospective clinical studies have shown that despite this plasma reversion, re-initiation of the same ARV agents (or those sharing similar resistance pathways) is usually associated with early drug failure, and that the virus present at failure is derived from previously archived resistant virus.<sup>15</sup> Therefore, resistance testing is of greatest value when performed before or within 4 weeks after drugs are discontinued (**AII**). Because resistant virus may persist in the plasma of some patients for longer periods of time, resistance testing done 4 to 6 weeks after discontinuation of drugs may still detect mutations. However, the absence of detectable resistance in such patients must be interpreted with caution when designing subsequent ARV regimens.

### *Use of Resistance Assays in Clinical Practice (See [Table 5](#))*

#### **Use of Resistance Assays in Determining Initial Treatment**

Transmission of drug-resistant HIV strains is well documented and associated with suboptimal virologic response to initial antiretroviral therapy (ART).<sup>16-19</sup> The likelihood that a patient will acquire drug-resistant virus is related to the prevalence of drug resistance in HIV-infected persons engaging in high-risk behaviors in the community. In the United States and Europe, recent studies suggest that the risk that transmitted virus will be resistant to at least one ARV drug is in the range of 6% to 16%.<sup>20-25</sup> Up to 8%, but generally less than 5% of transmitted viruses will exhibit resistance to drugs from more than one class.<sup>24, 26-28</sup>

If the decision is made to initiate therapy in a person with early HIV infection, resistance testing at baseline

can guide regimen selection to optimize virologic response. Therefore, resistance testing in this situation is recommended **(AII)**. A genotypic assay is preferred for this purpose **(AIII)**. In this setting, treatment initiation should not be delayed pending resistance testing results. Once results are obtained, the treatment regimen can be modified if warranted (see [Acute and Recent HIV Infection](#)). In the absence of therapy, resistant viruses may decline over time to less than the detection limit of standard resistance tests, but when therapy is eventually initiated, resistant viruses even at a low level may still increase the risk of treatment failure.<sup>29-31</sup> Therefore, if therapy is deferred, resistance testing should still be done during acute HIV infection **(AIII)**. In this situation, the genotypic resistance test result may be kept on record until the patient is to be started on ART. Repeat resistance testing at the time treatment is started should be considered because it is possible for a patient to acquire drug-resistant virus (i.e., superinfection) between entry into care and initiation of ART **(CIII)**.

Performing drug-resistance testing before ART initiation in patients with chronic HIV infection is less straightforward. The rate at which transmitted resistance-associated mutations revert to wild-type virus has not been completely delineated, but mutations present at the time of HIV transmission are more stable than those selected under drug pressure. It is often possible to detect resistance-associated mutations in viruses that were transmitted several years earlier.<sup>32-34</sup> No prospective trial has addressed whether drug-resistance testing before initiation of therapy confers benefit in this population. However, data from several, but not all, studies suggest that virologic responses in persons with baseline resistance mutations are suboptimal.<sup>16-19, 35-37</sup> In addition, a cost-effectiveness analysis of early genotypic resistance testing suggests that baseline testing in this population should be performed.<sup>38</sup> Therefore, resistance testing in chronically infected persons is recommended at the time of entry into HIV care **(AII)**. Although no definitive prospective data exist to support the choice of one type of resistance testing over another, genotypic testing is generally preferred in this situation because of lower cost, more rapid turnaround time, the assay's ability to detect mixtures of wild-type and resistant virus, and the relative ease of interpreting test results **(AIII)**. If therapy is deferred, repeat testing soon before initiation of ART should be considered because the patient may have acquired drug-resistant virus (i.e., superinfection) **(CIII)**.

Standard genotypic drug-resistance testing in ARV-naïve persons involves testing for mutations in the RT and PR genes. Although transmission of integrase strand transfer inhibitor (INSTI)-resistant virus has rarely been reported, as use of INSTIs increases, the potential for transmission of INSTI-resistant virus may also increase. Therefore, when INSTI resistance is suspected, providers may wish to supplement standard baseline genotypic resistance testing with genotypic testing for resistance to this class of drugs **(CIII)**.

### **Use of Resistance Assays in the Event of Virologic Failure**

Resistance assays are useful in guiding treatment decisions for patients who experience virologic failure while on ART. Several prospective studies assessed the utility of resistance testing to guide ARV drug selection in patients with virologic failure. These studies involved genotypic assays, phenotypic assays, or both.<sup>6, 39-45</sup> In general, these studies found that changes in therapy that were informed by resistance testing results produced better early virologic response to salvage regimens than regimen changes guided only by clinical judgment.

In addition, one observational cohort study found that performance of genotypic drug-resistance testing in ART-experienced patients with detectable plasma HIV RNA was independently associated with improved survival.<sup>46</sup> Thus, resistance testing is recommended as a tool in selecting active drugs when changing ARV regimens because of virologic failure in persons with HIV RNA >1,000 copies/mL **(AI)** (see [Virologic Failure and Suboptimal Immunologic Response](#)). In persons with HIV RNA >500 copies/mL but <1,000 copies/mL, testing may be unsuccessful but should still be considered **(BII)**. Drug-resistance testing in persons with a plasma viral load <500 copies/mL is not usually recommended because resistance assays cannot be consistently performed given low HIV RNA levels **(AIII)**.



Resistance testing also can help guide treatment decisions for patients with suboptimal viral load reduction **(AII)**. Virologic failure in the setting of combination ART is, for certain patients, associated with resistance to only one component of the regimen.<sup>47-49</sup> In this situation, substituting individual drugs in a failing regimen may be a possible option, but this concept will require clinical validation (see [Virologic Failure and Suboptimal Immunologic Response](#)).

In patients who are on a failing first or second ARV drug regimen and experiencing virologic failure or suboptimal viral load reduction, genotypic testing is generally preferred for resistance testing **(AII)**. This is based on the fact that, when compared with phenotypic testing, genotypic testing costs less to perform, has a faster turnaround time, and greater sensitivity for detecting mixtures of wild-type and resistant virus. In addition, observations show that the assays are comparable predictors of virologic response to subsequent ART regimens.<sup>50</sup>

Addition of phenotypic to genotypic testing is generally preferred for persons with known or suspected complex drug-resistance mutation patterns, particularly to PIs **(BIII)**.

In patients failing INSTI-based regimens, testing for INSTI resistance should be performed to determine whether to include drugs from this class in subsequent regimens **(AII)**; genotypic testing is preferred for this purpose.

When the use of a CCR5 antagonist is being considered, a co-receptor tropism assay should be performed **(AI)**. Phenotypic co-receptor tropism assays have been used in clinical practice. A genotypic assay to predict co-receptor use is now commercially available and is less expensive than phenotypic assays. Evaluation of genotypic assays is ongoing, but current data suggest that such testing should be considered as an alternative assay. The same principles regarding testing for co-receptor use also apply to testing when patients exhibit virologic failure on a CCR5 antagonist.<sup>51</sup> Resistance to CCR5 antagonists in the absence of detectable CXCR4-using virus has been reported, but such resistance is uncommon (see [Co-receptor Tropism Assays](#)).

### Use of Resistance Assays in Pregnant Women

In pregnant women, the goal of ART is to maximally reduce plasma HIV RNA to provide optimal maternal therapy and to prevent perinatal transmission of HIV. Genotypic resistance testing is recommended for all pregnant women before initiation of therapy **(AIII)** and for those entering pregnancy with detectable HIV RNA levels while on therapy **(AI)**. Phenotypic testing in those found to have complex drug-resistance mutation patterns, particularly to PIs, may provide additional information **(BIII)**. Optimal prevention of perinatal transmission may require initiation of ART pending resistance testing results. Once the results are available, the ARV regimen can be changed as needed.

**Table 5. Recommendations for Using Drug-Resistance Assays (page 1 of 2)**

Clinical Setting/Recommendation	Rationale
<b>Drug-resistance assay recommended</b>	
<p><b>In acute HIV infection:</b> Drug-resistance testing is recommended regardless of whether antiretroviral therapy (ART) is initiated immediately or deferred (<b>AII</b>). A genotypic assay is generally preferred (<b>AIII</b>).</p> <p>If ART is deferred, repeat resistance testing should be considered at the time therapy is initiated (<b>CIII</b>). A genotypic assay generally is preferred (<b>AIII</b>).</p>	<p>If ART is initiated immediately, drug-resistance testing can determine whether drug-resistant virus was transmitted. Test results will help in the design of initial regimens or to modify or change regimens if results are obtained after treatment initiation.</p> <p>Genotypic testing is preferred to phenotypic testing because of lower cost, faster turnaround time, and greater sensitivity for detecting mixtures of wild-type and resistant virus.</p> <p>If ART is deferred, testing should still be performed because of the greater likelihood that transmitted resistance-associated mutations will be detected earlier in the course of HIV infection. Results of resistance testing may be important when treatment is initiated. Repeat testing at the time ART is initiated should be considered because the patient may have acquired a drug-resistant virus (i.e., superinfection).</p>
<p><b>In ART-naïve patients with chronic HIV infection:</b> Drug-resistance testing is recommended at entry into HIV care, regardless of whether therapy is initiated immediately or deferred (<b>AII</b>). A genotypic assay is generally preferred (<b>AIII</b>).</p> <p>If therapy is deferred, repeat resistance testing should be considered before initiation of ART (<b>CIII</b>). A genotypic assay is generally preferred (<b>AIII</b>).</p> <p>If an INSTI is considered for an ART-naïve patient and transmitted INSTI resistance is a concern, providers may supplement standard resistance testing with a specific INSTI genotypic resistance assay (<b>CIII</b>).</p> <p>If use of a CCR5 antagonist is being considered, a co-receptor tropism assay should be performed (<b>AI</b>) (see <a href="#">Co-receptor Tropism Assays</a>)</p>	<p>Transmitted HIV with baseline resistance to at least 1 drug is seen in 6% to 16% of patients, and suboptimal virologic responses may be seen in patients with baseline resistant mutations. Some drug-resistance mutations can remain detectable for years in untreated, chronically infected patients.</p> <p>Repeat testing before initiation of ART should be considered because the patient may have acquired a drug-resistant virus (i.e., a superinfection).</p> <p>Genotypic testing is preferred to phenotypic testing because of lower cost, faster turnaround time, and greater sensitivity for detecting mixtures of wild-type and resistant virus.</p> <p>Standard genotypic drug-resistance assays test only for mutations in the RT and PR genes.</p> <p>(see <a href="#">Co-receptor Tropism Assays</a>)</p>
<p><b>In patients with virologic failure:</b> Drug-resistance testing is recommended in patients on combination ART with HIV RNA levels &gt;1,000 copies/mL (<b>AI</b>). In patients with HIV RNA levels &gt;500 copies/mL but &lt;1,000 copies/mL, testing may not be successful but should still be considered (<b>BII</b>).</p> <p>A standard genotypic resistance assay is generally preferred for patients experiencing virologic failure on their first or second regimens (<b>AII</b>).</p> <p>In patients failing INSTI-based regimens, genotypic testing for INSTI resistance should be performed to determine whether to include drugs from this class in subsequent regimens (<b>AII</b>).</p> <p>If use of a CCR5 antagonist is being considered, a co-receptor tropism assay should be performed (<b>AI</b>) (see <a href="#">Co-receptor Tropism Assays</a>).</p> <p>Addition of phenotypic assay to genotypic assay is generally preferred in patients with known or suspected complex drug-resistance patterns, particularly to protease inhibitors (PIs) (<b>BIII</b>).</p>	<p>Testing can help determine the role of resistance in drug failure and maximize the clinician's ability to select active drugs for the new regimen. Drug-resistance testing should be performed while the patient is taking prescribed ARV drugs or, if not possible, within 4 weeks after discontinuing therapy.</p> <p>Genotypic testing is preferred to phenotypic testing because of lower cost, faster turnaround time, and greater sensitivity for detecting mixtures of wild-type and resistant HIV.</p> <p>Standard genotypic drug-resistance assays test only for mutations in the RT and PR genes.</p> <p>Phenotypic testing can provide additional useful information in patients with complex drug-resistance mutation patterns, particularly to PIs.</p>

**Table 5. Recommendations for Using Drug-Resistance Assays (page 2 of 2)**

Clinical Setting/Recommendation	Rationale
<b>Drug-resistance assay recommended</b>	
<b>In patients with suboptimal suppression of viral load:</b> Drug-resistance testing is recommended in patients with suboptimal suppression of viral load after initiation of ART ( <b>AII</b> ).	Testing can help determine the role of resistance and thus assist the clinician in identifying the number of active drugs available for a new regimen.
<b>In HIV-infected pregnant women:</b> Genotypic resistance testing is recommended for all pregnant women before initiation of ART ( <b>AIII</b> ) and for those entering pregnancy with detectable HIV RNA levels while on therapy ( <b>AI</b> ).	The goal of ART in HIV-infected pregnant women is to achieve maximal viral suppression for treatment of maternal HIV infection and for prevention of perinatal transmission of HIV. Genotypic resistance testing will assist the clinician in selecting the optimal regimen for the patient.
<b>Drug-resistance assay not usually recommended</b>	
<b>After therapy is discontinued:</b> Drug-resistance testing is not usually recommended more than 4 weeks after discontinuation of ARV drugs ( <b>BIII</b> ).	Drug-resistance mutations may become minor species in the absence of selective drug pressure, and available assays may not detect minor drug-resistant species. If testing is performed in this setting, the detection of drug resistance may be of value; however, the absence of resistance does not rule out the presence of minor drug-resistant species.
<b>In patients with low HIV RNA levels:</b> Drug-resistance testing is not usually recommended in patients with a plasma viral load <500 copies/mL ( <b>AIII</b> ).	Resistance assays cannot be consistently performed given low HIV RNA levels.

## References

1. Hirsch MS, Gunthard HF, Schapiro JM, et al. Antiretroviral drug-resistance testing in adult HIV-1 infection: 2008 recommendations of an International AIDS Society-USA panel. *Clin Infect Dis*. 2008;47(2):266-285. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18549313](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18549313).
2. Flandre P, Costagliola D. On the comparison of artificial network and interpretation systems based on genotype resistance mutations in HIV-1-infected patients. *AIDS*. 2006;20(16):2118-2120. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17053360](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17053360).
3. Vercauteren J, Vandamme AM. Algorithms for the interpretation of HIV-1 genotypic drug resistance information. *Antiviral Res*. 2006;71(2-3):335-342. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=16782210](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16782210).
4. Gianotti N, Mondino V, Rossi MC, et al. Comparison of a rule-based algorithm with a phenotype-based algorithm for the interpretation of HIV genotypes in guiding salvage regimens in HIV-infected patients by a randomized clinical trial: the mutations and salvage study. *Clin Infect Dis*. 2006;42(10):1470-1480. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=16619162](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16619162).
5. Torti C, Quiros-Roldan E, Regazzi M, et al. A randomized controlled trial to evaluate antiretroviral salvage therapy guided by rules-based or phenotype-driven HIV-1 genotypic drug-resistance interpretation with or without concentration-controlled intervention: the Resistance and Dosage Adapted Regimens (RADAR) study. *Clin Infect Dis*. 2005;40(12):1828-1836. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=15909273](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15909273).
6. Tural C, Ruiz L, Holtzer C, et al. Clinical utility of HIV-1 genotyping and expert advice: the Havana trial. *AIDS*. 2002;16(2):209-218. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=11807305](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11807305).
7. Lanier ER, Ait-Khaled M, Scott J, et al. Antiviral efficacy of abacavir in antiretroviral therapy-experienced adults harbouring HIV-1 with specific patterns of resistance to nucleoside reverse transcriptase inhibitors. *Antivir Ther*. 2004;9(1):37-45. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=15040535](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15040535).

8. Miller MD, Margot N, Lu B, et al. Genotypic and phenotypic predictors of the magnitude of response to tenofovir disoproxil fumarate treatment in antiretroviral-experienced patients. *J Infect Dis*. 2004;189(5):837-846. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=14976601](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=14976601).
9. Flandre P, Chappey C, Marcelin AG, et al. Phenotypic susceptibility to didanosine is associated with antiviral activity in treatment-experienced patients with HIV-1 infection. *J Infect Dis*. 2007;195(3):392-398. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17205478](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17205478).
10. Naeger LK, Struble KA. Food and Drug Administration analysis of tipranavir clinical resistance in HIV-1-infected treatment-experienced patients. *AIDS*. 2007;21(2):179-185. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17197808](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17197808).
11. Naeger LK, Struble KA. Effect of baseline protease genotype and phenotype on HIV response to atazanavir/ritonavir in treatment-experienced patients. *AIDS*. 2006;20(6):847-853. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=16549968](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16549968).
12. Verhofstede C, Wanseele FV, Van Der Gucht B, De Cabooter N, Plum J. Interruption of reverse transcriptase inhibitors or a switch from reverse transcriptase to protease inhibitors resulted in a fast reappearance of virus strains with a reverse transcriptase inhibitor-sensitive genotype. *AIDS*. 1999;13(18):2541-2546. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=10630523](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=10630523).
13. Miller V, Sabin C, Hertogs K, et al. Virological and immunological effects of treatment interruptions in HIV-1 infected patients with treatment failure. *AIDS*. 2000;14(18):2857-2867. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=11153667](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11153667).
14. Devereux HL, Youle M, Johnson MA, Loveday C. Rapid decline in detectability of HIV-1 drug resistance mutations after stopping therapy. *AIDS*. 1999;13(18):F123-127. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=10630517](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=10630517).
15. Benson CA, Vaida F, Havlir DV, et al. A randomized trial of treatment interruption before optimized antiretroviral therapy for persons with drug-resistant HIV: 48-week virologic results of ACTG A5086. *J Infect Dis*. 2006;194(9):1309-1318. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17041858](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17041858).
16. Little SJ, Holte S, Routy JP, et al. Antiretroviral-drug resistance among patients recently infected with HIV. *N Engl J Med*. 2002;347(6):385-394. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=12167680](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=12167680).
17. Borroto-Esoda K, Waters JM, Bae AS, et al. Baseline genotype as a predictor of virological failure to emtricitabine or stavudine in combination with didanosine and efavirenz. *AIDS Res Hum Retroviruses*. 2007;23(8):988-995. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17725415](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17725415).
18. Pozniak AL, Gallant JE, DeJesus E, et al. Tenofovir disoproxil fumarate, emtricitabine, and efavirenz versus fixed-dose zidovudine/lamivudine and efavirenz in antiretroviral-naïve patients: virologic, immunologic, and morphologic changes—a 96-week analysis. *J Acquir Immune Defic Syndr*. 2006;43(5):535-540. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17057609](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17057609).
19. Kuritzkes DR, Lalama CM, Ribaudo HJ, et al. Preexisting resistance to nonnucleoside reverse-transcriptase inhibitors predicts virologic failure of an efavirenz-based regimen in treatment-naïve HIV-1-infected subjects. *J Infect Dis*. 2008;197(6):867-870. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18269317](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18269317).
20. Weinstock HS, Zaidi I, Heneine W, et al. The epidemiology of antiretroviral drug resistance among drug-naïve HIV-1-infected persons in 10 U.S. cities. *J Infect Dis*. 2004;189(12):2174-2180. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=15181563](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15181563).
21. Wensing AM, van de Vijver DA, Angarano G, et al. Prevalence of drug-resistant HIV-1 variants in untreated individuals in Europe: implications for clinical management. *J Infect Dis*. 2005;192(6):958-966. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=16107947](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16107947).
22. Cane P, Chrystie I, Dunn D, et al. Time trends in primary resistance to HIV drugs in the United Kingdom: multicentre observational study. *BMJ*. 2005;331(7529):1368. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=16299012](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16299012).
23. Bennett D, McCormick L, Kline R, et al. U.S. surveillance of HIV drug resistance at diagnosis using HIV diagnostic sera. Paper presented at: 12th Conference on Retroviruses and Opportunistic Infections. 2005. Boston, MA.

24. Wheeler WH, Ziebell RA, Zabina H, et al. Prevalence of transmitted drug resistance associated mutations and HIV-1 subtypes in new HIV-1 diagnoses, U.S.-2006. *AIDS*. 2010;24(8):1203-1212. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=20395786](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20395786).
25. Ross L, Lim ML, Liao Q, et al. Prevalence of antiretroviral drug resistance and resistance-associated mutations in antiretroviral therapy-naïve HIV-infected individuals from 40 United States cities. *HIV Clin Trials*. 2007;8(1):1-8. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17434843](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17434843).
26. Yanik EL, Napravnik S, Hurt CB, et al. Prevalence of transmitted antiretroviral drug resistance differs between acutely and chronically HIV-infected patients. *J Acquir Immune Defic Syndr*. 2012;61(2):258-262. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22692092>.
27. Agwu AL, Bethel J, Hightow-Weidman LB, et al. Substantial multiclass transmitted drug resistance and drug-relevant polymorphisms among treatment-naïve behaviorally HIV-infected youth. *AIDS Patient Care STDS*. 2012;26(4):193-196. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22563607>.
28. Castor D, Low A, Evering T, et al. Transmitted drug resistance and phylogenetic relationships among acute and early HIV-1-infected individuals in New York City. *J Acquir Immune Defic Syndr*. 2012;61(1):1-8. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22592583>.
29. Johnson JA, Li JF, Wei X, et al. Minority HIV-1 drug resistance mutations are present in antiretroviral treatment-naïve populations and associate with reduced treatment efficacy. *PLoS Med*. 2008;5(7):e158. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18666824](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18666824).
30. Simen BB, Simons JF, Hullsiek KH, et al. Low-abundance drug-resistant viral variants in chronically HIV-infected, antiretroviral treatment-naïve patients significantly impact treatment outcomes. *J Infect Dis*. 2009;199(5):693-701. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19210162](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19210162).
31. Paredes R, Lalama CM, Ribaud HJ, et al. Pre-existing minority drug-resistant HIV-1 variants, adherence, and risk of antiretroviral treatment failure. *J Infect Dis*. 2010;201(5):662-671. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=20102271](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20102271).
32. Smith DM, Wong JK, Shao H, et al. Long-term persistence of transmitted HIV drug resistance in male genital tract secretions: implications for secondary transmission. *J Infect Dis*. 2007;196(3):356-360. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17597449](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17597449).
33. Novak RM, Chen L, MacArthur RD, et al. Prevalence of antiretroviral drug resistance mutations in chronically HIV-infected, treatment-naïve patients: implications for routine resistance screening before initiation of antiretroviral therapy. *Clin Infect Dis*. 2005;40(3):468-474. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=15668873](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15668873).
34. Little SJ, Frost SD, Wong JK, et al. Persistence of transmitted drug resistance among subjects with primary human immunodeficiency virus infection. *J Virol*. 2008;82(11):5510-5518. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18353964](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18353964).
35. Saag MS, Cahn P, Raffi F, et al. Efficacy and safety of emtricitabine vs stavudine in combination therapy in antiretroviral-naïve patients: a randomized trial. *JAMA*. 2004;292(2):180-189. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=15249567](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15249567).
36. Jourdain G, Ngo-Giang-Huong N, Le Coeur S, et al. Intrapartum exposure to nevirapine and subsequent maternal responses to nevirapine-based antiretroviral therapy. *N Engl J Med*. 2004;351(3):229-240. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=15247339](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15247339).
37. Pillay D, Bhaskaran K, Jurriaans S, et al. The impact of transmitted drug resistance on the natural history of HIV infection and response to first-line therapy. *AIDS*. 2006;20(1):21-28. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=16327315](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16327315).
38. Sax PE, Islam R, Walensky RP, et al. Should resistance testing be performed for treatment-naïve HIV-infected patients? A cost-effectiveness analysis. *Clin Infect Dis*. 2005;41(9):1316-1323. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=16206108](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16206108).
39. Cingolani A, Antinori A, Rizzo MG, et al. Usefulness of monitoring HIV drug resistance and adherence in individuals failing highly active antiretroviral therapy: a randomized study (ARGENTA). *AIDS*. 2002;16(3):369-379. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=11834948](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11834948).



40. Durant J, Clevenbergh P, Halfon P, et al. Drug-resistance genotyping in HIV-1 therapy: the VIRADAPT randomised controlled trial. *Lancet*. 1999;353(9171):2195-2199. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=10392984](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=10392984).
41. Baxter JD, Mayers DL, Wentworth DN, et al; for the CPCRA 046 Study Team for the Terry Bein Community Programs for Clinical Research on AIDS. A randomized study of antiretroviral management based on plasma genotypic antiretroviral resistance testing in patients failing therapy. *AIDS*. 2000;14(9):F83-93. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list\\_uids=10894268&dopt=Abstract](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uids=10894268&dopt=Abstract).
42. Cohen CJ, Hunt S, Sension M, et al. A randomized trial assessing the impact of phenotypic resistance testing on antiretroviral therapy. *AIDS*. 2002;16(4):579-588. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=11873001](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11873001).
43. Meynard JL, Vray M, Morand-Joubert L, et al. Phenotypic or genotypic resistance testing for choosing antiretroviral therapy after treatment failure: a randomized trial. *AIDS*. 2002;16(5):727-736. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=11964529](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11964529).
44. Vray M, Meynard JL, Dalban C, et al. Predictors of the virological response to a change in the antiretroviral treatment regimen in HIV-1-infected patients enrolled in a randomized trial comparing genotyping, phenotyping and standard of care (Narval trial, ANRS 088). *Antivir Ther*. 2003;8(5):427-434. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=14640390](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=14640390).
45. Wegner SA, Wallace MR, Aronson NE, et al. Long-term efficacy of routine access to antiretroviral-resistance testing in HIV type 1-infected patients: results of the clinical efficacy of resistance testing trial. *Clin Infect Dis*. 2004;38(5):723-730. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=14986258](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=14986258).
46. Palella FJ, Jr., Armon C, Buchacz K, et al. The association of HIV susceptibility testing with survival among HIV-infected patients receiving antiretroviral therapy: a cohort study. *Ann Intern Med*. 2009;151(2):73-84. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19620160](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19620160).
47. Havlir DV, Hellmann NS, Petropoulos CJ, et al. Drug susceptibility in HIV infection after viral rebound in patients receiving indinavir-containing regimens. *JAMA*. 2000;283(2):229-234. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=10634339](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=10634339).
48. Descamps D, Flandre P, Calvez V, et al. Mechanisms of virologic failure in previously untreated HIV-infected patients from a trial of induction-maintenance therapy. Trilege (Agence Nationale de Recherches sur le SIDA 072) Study Team). *JAMA*. 2000;283(2):205-211. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=10634336](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=10634336).
49. Machouf N, Thomas R, Nguyen VK, et al. Effects of drug resistance on viral load in patients failing antiretroviral therapy. *J Med Virol*. 2006;78(5):608-613. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=16555280](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16555280).
50. Anderson JA, Jiang H, Ding X, et al. Genotypic susceptibility scores and HIV type 1 RNA responses in treatment-experienced subjects with HIV type 1 infection. *AIDS Res Hum Retroviruses*. 2008;24(5):685-694. Available at <http://www.ncbi.nlm.nih.gov/pubmed/18462083>.
51. Lewis M MJ, Simpson P, et al. Changes in V3 loop sequence associated with failure of maraviroc treatment in patients enrolled in the MOTIVATE 1 and 2 trials. Paper presented at: 15th Conference on Retroviruses and Opportunistic Infections. 2008; Boston, MA.

## Co-Receptor Tropism Assays (Last updated February 12, 2013; last reviewed February 12, 2013)

Panel's Recommendations
<ul style="list-style-type: none"><li>A co-receptor tropism assay should be performed whenever the use of a CCR5 co-receptor antagonist is being considered (AI).</li><li>Co-receptor tropism testing is also recommended for patients who exhibit virologic failure on a CCR5 antagonist (BIII).</li><li>A phenotypic tropism assay is preferred to determine HIV-1 co-receptor usage (AI).</li><li>A genotypic tropism assay should be considered as an alternative test to predict HIV-1 co-receptor usage (BII).</li></ul>
<b>Rating of Recommendations:</b> A = Strong; B = Moderate; C = Optional
<b>Rating of Evidence:</b> I = Data from randomized controlled trials; II = Data from well-designed nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion

HIV enters cells by a complex process that involves sequential attachment to the CD4 receptor followed by binding to either the CCR5 or CXCR4 molecules and fusion of the viral and cellular membranes.<sup>1</sup> CCR5 co-receptor antagonists prevent HIV entry into target cells by binding to the CCR5 receptors.<sup>2</sup> Phenotypic and, to a lesser degree, genotypic assays have been developed that can determine or predict the co-receptor tropism (i.e., CCR5, CXCR4, or both) of the patient's dominant virus population. An older generation assay (*Trofile*, Monogram Biosciences, Inc., South San Francisco, CA) was used to screen patients who were participating in clinical trials that led to the approval of maraviroc (MVC), the only CCR5 antagonist currently available. The assay has been improved and is now available with enhanced sensitivity. In addition, a genotypic assay to predict co-receptor usage is now commercially available.

During acute/recent infection, the vast majority of patients harbor a CCR5-utilizing virus (R5 virus), which suggests that the R5 variant is preferentially transmitted. Viruses in many untreated patients eventually exhibit a shift in co-receptor tropism from CCR5 usage to either CXCR4 or both CCR5 and CXCR4 tropism (i.e., dual- or mixed-tropic; D/M-tropic). This shift is temporally associated with a more rapid decline in CD4 T-cell counts,<sup>3,4</sup> but whether this tropism shift is a cause or a consequence of progressive immunodeficiency remains undetermined.<sup>1</sup> Antiretroviral (ARV)-treated patients with extensive drug resistance are more likely to harbor X4- or D/M-tropic variants than untreated patients with comparable CD4 counts.<sup>5</sup> The prevalence of X4- or D/M-tropic variants increases to more than 50% in treated patients who have CD4 counts <100 cells/mm<sup>3</sup>.<sup>5,6</sup>

### Phenotypic Assays

Phenotypic assays characterize the co-receptor usage of plasma-derived virus. These assays involve the generation of laboratory viruses that express patient-derived envelope proteins (i.e., gp120 and gp41). These pseudoviruses, which are replication-defective, are used to infect target cell lines that express either CCR5 or CXCR4.<sup>7,8</sup> Using the *Trofile* assay, the co-receptor tropism of the patient-derived virus is confirmed by testing the susceptibility of the virus to specific CCR5 or CXCR4 inhibitors *in vitro*. This assay takes about 2 weeks to perform and requires a plasma HIV RNA level  $\geq 1,000$  copies/mL.

The performance characteristics of these assays have evolved. Most, if not all, patients enrolled in pre-marketing clinical trials of MVC and other CCR5 antagonists were screened with an earlier, less sensitive version of the *Trofile* assay.<sup>8</sup> This earlier assay failed to routinely detect low levels of CXCR4-utilizing variants. As a consequence, some patients enrolled in these clinical trials harbored low levels of CXCR4-utilizing virus at baseline that were below the assay limit of detection and exhibited rapid virologic failure after initiation of a CCR5 antagonist.<sup>9</sup> The assay has been revised and is now able to detect lower levels of CXCR4-utilizing viruses. *In vitro*, the assay can detect CXCR4-utilizing clones with 100% sensitivity when those clones represent 0.3% or more of the virus population.<sup>10</sup> Although this more sensitive assay has had limited use in prospective clinical trials, it is now the only one that is commercially available. For unclear

reasons, a minority of samples cannot be successfully phenotyped with either generation of the *Trofile* assay.

In patients with plasma HIV-1 RNA below the limit of detection, co-receptor usage can be determined from proviral DNA obtained from peripheral blood mononuclear cells; however, the clinical utility of this assay remains to be determined.<sup>11</sup>

### ***Genotypic Assays***

Genotypic determination of HIV-1 co-receptor usage is based on sequencing of the V3-coding region of HIV-1 *env*, the principal determinant of co-receptor usage. A variety of algorithms and bioinformatics programs can be used to predict co-receptor usage from the V3 sequence. When compared to the phenotypic assay, genotypic methods show high specificity (~90%) but only modest sensitivity (~50%–70%) for the presence of a CXCR4-utilizing virus. Given these performance characteristics, these assays may not be sufficiently robust to completely rule out the presence of an X4 or D/M variant.<sup>12</sup>

Studies in which V3 genotyping was performed on samples from patients screened for clinical trials of MVC suggest that genotyping performed as well as phenotyping in predicting the response to MVC.<sup>13–15</sup> On the basis of these data, accessibility, and cost, European guidelines currently favor genotypic testing to determine co-receptor usage.<sup>16</sup> An important caveat to these results is that the majority of patients who received MVC were first shown to have R5 virus by a phenotypic assay (*Trofile*). Consequently, the opportunity to assess treatment response to MVC in patients whose virus was considered R5 by genotype but D/M or X4 by phenotype was limited to a relatively small number of patients.

### ***Use of Assays to Determine Co-Receptor Usage in Clinical Practice***

An assay for HIV-1 co-receptor usage should be performed whenever the use of a CCR5 antagonist is being considered (**AI**). In addition, because virologic failure may occur due to a shift from CCR5-using to CXCR4-using virus, testing for co-receptor usage is recommended in patients who exhibit virologic failure on a CCR5 antagonist (**BIII**). Virologic failure also may be caused by resistance of a CCR5-using virus to a CCR5 antagonist, but such resistance is uncommon. Compared to genotypic testing, phenotypic testing has more evidence supporting its usefulness. Therefore, a phenotypic test for co-receptor usage is generally preferred (**AI**). However, because phenotypic testing is more expensive and requires more time to perform, a genotypic test to predict HIV-1 co-receptor usage should be considered as an alternative test (**BII**).

A tropism assay may potentially be used in clinical practice for prognostic purposes or to assess tropism before starting ART if future use of a CCR5 antagonist is anticipated (e.g., a regimen change for toxicity). Currently, sufficient data do not exist to support these uses.

## **References**

1. Moore JP, Kitchen SG, Pugach P, Zack JA. The CCR5 and CXCR4 coreceptors—central to understanding the transmission and pathogenesis of human immunodeficiency virus type 1 infection. *AIDS Res Hum Retroviruses*. 2004;20(1):111–126. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=15000703](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15000703).
2. Fatkenheuer G, Pozniak AL, Johnson MA, et al. Efficacy of short-term monotherapy with maraviroc, a new CCR5 antagonist, in patients infected with HIV-1. *Nat Med*. 2005;11(11):1170–1172. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=16205738](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16205738).
3. Connor RI, Sheridan KE, Ceradini D, Choe S, Landau NR. Change in coreceptor use correlates with disease progression in HIV-1-infected individuals. *J Exp Med*. 1997;185(4):621–628. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=9034141](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=9034141).
4. Koot M, Keet IP, Vos AH, et al. Prognostic value of HIV-1 syncytium-inducing phenotype for rate of CD4+ cell depletion and progression to AIDS. *Ann Intern Med*. 1993;118(9):681–688. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=8096374](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=8096374).



5. Hunt PW, Harrigan PR, Huang W, et al. Prevalence of CXCR4 tropism among antiretroviral-treated HIV-1-infected patients with detectable viremia. *J Infect Dis.* 2006;194(7):926-930. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=16960780](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16960780).
6. Wilkin TJ, Su Z, Kuritzkes DR, et al. HIV type 1 chemokine coreceptor use among antiretroviral-experienced patients screened for a clinical trial of a CCR5 inhibitor: AIDS Clinical Trial Group A5211. *Clin Infect Dis.* 2007;44(4):591-595. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17243065](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17243065).
7. Troupin V, Salvatori F, Cappello F, et al. Determination of coreceptor usage of human immunodeficiency virus type 1 from patient plasma samples by using a recombinant phenotypic assay. *J Virol.* 2001;75(1):251-259. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=11119595](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11119595).
8. Whitcomb JM, Huang W, Fransen S, et al. Development and characterization of a novel single-cycle recombinant-virus assay to determine human immunodeficiency virus type 1 coreceptor tropism. *Antimicrob Agents Chemother.* 2007;51(2):566-575. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17116663](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17116663).
9. Westby M, Lewis M, Whitcomb J, et al. Emergence of CXCR4-using human immunodeficiency virus type 1 (HIV-1) variants in a minority of HIV-1-infected patients following treatment with the CCR5 antagonist maraviroc is from a pretreatment CXCR4-using virus reservoir. *J Virol.* 2006;80(10):4909-4920. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=16641282](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16641282).
10. Trinh L, Han D, Huang W, et al. Technical validation of an enhanced sensitivity Trofile HIV coreceptor tropism assay for selecting patients for therapy with entry inhibitors targeting CCR5. *Antivir Ther.* 2008;13(Suppl 3):A128
11. Toma J, Frantzell A, Cook J, et al. Phenotypic determination of HIV-1 coreceptor tropism using cell-associated DNA derived from blood samples. Paper presented at: 17th Conference on Retroviruses and Opportunistic Infections; 2010; San Francisco, CA.
12. Lin NH, Kuritzkes DR. Tropism testing in the clinical management of HIV-1 infection. *Curr Opin HIV AIDS.* 2009;4(6):481-487. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=20048714](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20048714).
13. McGovern RA, Thielen A, Mo T, et al. Population-based V3 genotypic tropism assay: a retrospective analysis using screening samples from the A4001029 and MOTIVATE studies. *AIDS.* 2010;24(16):2517-2525. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=20736814](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20736814).
14. McGovern RA, Thielen A, Portsmouth S, et al. Population-based sequencing of the V3-loop can predict the virological response to maraviroc in treatment-naïve patients of the MERIT trial. *J Acquir Immune Defic Syndr.* 2012;61(3):279-286. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23095934>.
15. Archer J, Weber J, Henry K, et al. Use of four next-generation sequencing platforms to determine HIV-1 coreceptor tropism. *PLoS One.* 2012;7(11):e49602. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23166726>.
16. Vandekerckhove LP, Wensing AM, Kaiser R, et al. European guidelines on the clinical management of HIV-1 tropism testing. *Lancet Infect Dis.* 2011;11(5):394-407. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21429803>.

## HLA-B\*5701 Screening (Last updated December 1, 2007; last reviewed January 10, 2011)

### Panel's Recommendations

- The Panel recommends screening for HLA-B\*5701 before starting patients on an abacavir (ABC)-containing regimen to reduce the risk of hypersensitivity reaction (HSR) **(AI)**.
- HLA-B\*5701-positive patients should not be prescribed ABC **(AI)**.
- The positive status should be recorded as an ABC allergy in the patient's medical record **(AII)**.
- When HLA-B\*5701 screening is not readily available, it remains reasonable to initiate ABC with appropriate clinical counseling and monitoring for any signs of HSR **(CIII)**.

**Rating of Recommendations:** A = Strong; B = Moderate; C = Optional

**Rating of Evidence:** I = Data from randomized controlled trials; II = Data from well-designed nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion

The ABC HSR is a multiorgan clinical syndrome typically seen within the initial 6 weeks of ABC treatment. This reaction has been reported in 5%–8% of patients participating in clinical trials when using clinical criteria for the diagnosis, and it is the major reason for early discontinuation of ABC. Discontinuing ABC usually promptly reverses HSR, whereas subsequent rechallenge can cause a rapid, severe, and even life-threatening recurrence.<sup>1</sup>

Studies that evaluated demographic risk factors for ABC HSR have shown racial background as a risk factor, with white patients generally having a higher risk (5%–8%) than black patients (2%–3%). Several groups reported a highly significant association between ABC HSR and the presence of the major histocompatibility complex (MHC) class I allele HLA-B\*5701.<sup>2–3</sup> Because the clinical criteria used for ABC HSR are overly sensitive and may lead to false-positive ABC HSR diagnoses, an ABC skin patch test (SPT) was developed as a research tool to immunologically confirm ABC HSR.<sup>4</sup> A positive ABC SPT is an ABC-specific delayed HSR that results in redness and swelling at the skin site of application. All ABC SPT–positive patients studied were also positive for the HLA-B\*5701 allele.<sup>5</sup> The ABC SPT could be falsely negative for some patients with ABC HSR and, at this point, is not recommended for use as a clinical tool. The PREDICT-1 study randomized patients before starting ABC either to be prospectively screened for HLA-B\*5701 (with HLA-B\*5701–positive patients not offered ABC) or to standard of care at the time of the study (i.e., no HLA screening, with all patients receiving ABC).<sup>6</sup> The overall HLA-B\*5701 prevalence in this predominately white population was 5.6%. In this cohort, screening for HLA-B\*5701 eliminated immunologic ABC HSR (defined as ABC SPT positive) compared with standard of care (0% vs. 2.7%), yielding a 100% negative predictive value with respect to SPT and significantly decreasing the rate of clinically suspected ABC HSR (3.4% vs. 7.8%). The SHAPE study corroborated the low rate of immunologically validated ABC HSR in black patients and confirmed the utility of HLA-B\*5701 screening for the risk of ABC HSR (100% sensitivity in black and white populations).<sup>7</sup>

On the basis of the results of these studies, the Panel recommends screening for HLA-B\*5701 before starting patients on an ABC-containing regimen **(AI)**. HLA-B\*5701–positive patients should not be prescribed ABC **(AI)**, and the positive status should be recorded as an ABC allergy in the patient's medical record **(AII)**. HLA-B\*5701 testing is needed only once in a patient's lifetime; thus, efforts to carefully record and maintain the test result and to educate the patient about its implications are important. The specificity of the HLA-B\*5701 test in predicting ABC HSR is lower than the sensitivity (i.e., 33%–50% of HLA-B\*5701–positive patients would likely not develop confirmed ABC HSR if exposed to ABC). HLA-B\*5701 should not be used as a substitute for clinical judgment or pharmacovigilance, because a negative HLA-B\*5701 result does not absolutely rule out the possibility of some form of ABC HSR. When HLA-B\*5701 screening is not

readily available, it remains reasonable to initiate ABC with appropriate clinical counseling and monitoring for any signs of ABC HSR (CIII).

## References

1. Hetherington S, McGuirk S, Powell G, et al. Hypersensitivity reactions during therapy with the nucleoside reverse transcriptase inhibitor abacavir. *Clin Ther*. 2001;23(10):1603-1614.
2. Mallal S, Nolan D, Witt C, et al. Association between presence of HLA-B\*5701, HLA-DR7, and HLA-DQ3 and hypersensitivity to HIV-1 reverse-transcriptase inhibitor abacavir. *Lancet*. 2002;359(9308):727-732.
3. Hetherington S, Hughes AR, Mosteller M, et al. Genetic variations in HLA-B region and hypersensitivity reactions to abacavir. *Lancet*. 2002;359(9312):1121-1122.
4. Phillips EJ, Sullivan JR, Knowles SR, et al. Utility of patch testing in patients with hypersensitivity syndromes associated with abacavir. *AIDS*. 2002;16(16):2223-2225.
5. Phillips E, Rauch A, Nolan D, et al. Pharmacogenetics and clinical characteristics of patch test confirmed patients with abacavir hypersensitivity. *Rev Antivir Ther*. 2006;3: Abstract 57.
6. Mallal S, Phillips E, Carosi G, et al. HLA-B\*5701 screening for hypersensitivity to abacavir. *N Engl J Med*. 2008;358(6):568-579.
7. Saag M, Balu R, Phillips E, et al. High sensitivity of human leukocyte antigen-b\*5701 as a marker for immunologically confirmed abacavir hypersensitivity in white and black patients. *Clin Infect Dis*. 2008;46(7):1111-1118.

Antiretroviral therapy (ART) has reduced HIV-related morbidity and mortality at all stages of HIV infection<sup>1-4</sup> and has reduced HIV transmission.<sup>5-8</sup> Maximal and durable suppression of plasma viremia delays or prevents the selection of drug-resistance mutations, preserves or improves CD4 T lymphocyte (CD4) cell numbers, and confers substantial clinical benefits, all of which are important treatment goals.<sup>9,10</sup> HIV suppression with ART may also decrease inflammation and immune activation thought to contribute to higher rates of cardiovascular and other end-organ damage reported in HIV-infected cohorts (see [Initiating Antiretroviral Therapy](#)). Despite these benefits, eradication of HIV infection cannot be achieved with available antiretrovirals (ARVs). Treatment interruption has been associated with rebound viremia, worsening of immune function, and increased morbidity and mortality.<sup>11</sup> Thus, once initiated, ART should be continued, with the following key treatment goals:

- Maximally and durably suppress plasma HIV RNA,
- Restore and preserve immunologic function,
- Reduce HIV-associated morbidity and prolong the duration and quality of survival, and
- Prevent HIV transmission.

Achieving viral suppression currently requires the use of combination ARV regimens that generally include three active drugs from two or more drug classes. Baseline patient characteristics and results from drug resistance testing should guide design of the specific regimen (see [What to Start: Initial Combination Regimens for the Antiretroviral-Naïve Patient](#)). When initial HIV suppression is not achieved or not maintained, changing to a new regimen with at least two active drugs is often required (see [Virologic Failure](#)).

The increasing number of ARV drugs and drug classes makes viral suppression below detection limits an achievable goal in most patients.

After initiation of effective ART, viral load reduction to below limits of assay detection usually occurs within the first 12 to 24 weeks of therapy. Predictors of virologic success include:

- low baseline viremia,
- high potency of the ARV regimen,
- tolerability of the regimen,
- convenience of the regimen,
- excellent adherence to the regimen.

## Strategies to Achieve Treatment Goals

### *Selection of Initial Combination Regimen*

Several ARV regimens are recommended for use in ART-naïve patients (see [What to Start](#)). Most of the recommended regimens have comparable efficacy but vary in pill burden, potential for drug interactions and/or side effects, and propensity to select for resistance mutations if ART adherence is suboptimal. Regimens should be tailored for the individual patient to enhance adherence and support long-term treatment success.

Considerations when selecting an ARV regimen for an individual patient include potential side effects, patient comorbidities, possible interactions with concomitant medications, results of pretreatment genotypic drug-resistance testing, and regimen convenience (see [Table 7](#)).

### *Improving Adherence*

Suboptimal adherence may result in reduced treatment response. Incomplete adherence can result from complex medication regimens; patient-related factors, such as active substance abuse, depression, or the experience of adverse effects; and health system issues, including interruptions in patient access to medication and inadequate

treatment education and support. Conditions that promote adherence should be maximized before and after initiation of ART. (See [Adherence to Antiretroviral Therapy](#).)

## References

1. Severe P, Juste MA, Ambroise A, et al. Early versus standard antiretroviral therapy for HIV-infected adults in Haiti. *N Engl J Med*. Jul 15 2010;363(3):257-265. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=20647201](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20647201).
2. INSIGHT START Study Group. Initiation of antiretroviral therapy in early asymptomatic HIV infection. *N Engl J Med*. Jul 20 2015. Available at <http://www.ncbi.nlm.nih.gov/pubmed/26192873>.
3. TEMPRANO ANRS Study Group, Danel C, Moh R, et al. A trial of early antiretrovirals and isoniazid preventive therapy in africa. *N Engl J Med*. Aug 27 2015;373(9):808-822. Available at <http://www.ncbi.nlm.nih.gov/pubmed/26193126>.
4. Kitahata MM, Gange SJ, Abraham AG, et al. Effect of early versus deferred antiretroviral therapy for HIV on survival. *N Engl J Med*. Apr 30 2009;360(18):1815-1826. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19339714](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19339714).
5. Mofenson LM, Lambert JS, Stiehlm ER, et al. Risk factors for perinatal transmission of human immunodeficiency virus type 1 in women treated with zidovudine. Pediatric AIDS Clinical Trials Group Study 185 Team. *N Engl J Med*. Aug 5 1999;341(6):385-393. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=10432323](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=10432323).
6. Wood E, Kerr T, Marshall BD, et al. Longitudinal community plasma HIV-1 RNA concentrations and incidence of HIV-1 among injecting drug users: prospective cohort study. *BMJ*. 2009;338:b1649. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19406887](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19406887).
7. Cohen MS, Chen YQ, McCauley M, et al. Prevention of HIV-1 infection with early antiretroviral therapy. *N Engl J Med*. Aug 11 2011;365(6):493-505. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=21767103](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=21767103).
8. Reynolds SJ, Makumbi F, Nakigozi G, et al. HIV-1 transmission among HIV-1 discordant couples before and after the introduction of antiretroviral therapy. *AIDS*. Feb 20 2011;25(4):473-477. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21160416>.
9. O'Brien WA, Hartigan PM, Martin D, et al. Changes in plasma HIV-1 RNA and CD4+ lymphocyte counts and the risk of progression to AIDS. Veterans Affairs Cooperative Study Group on AIDS. *N Engl J Med*. Feb 15 1996;334(7):426-431. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=8552144](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=8552144).
10. Garcia F, de Lazzari E, Plana M, et al. Long-term CD4+ T-cell response to highly active antiretroviral therapy according to baseline CD4+ T-cell count. *J Acquir Immune Defic Syndr*. Jun 1 2004;36(2):702-713. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=15167289](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15167289).
11. El-Sadr WM, Lundgren JD, Neaton JD, et al. CD4+ count-guided interruption of antiretroviral treatment. *N Engl J Med*. Nov 30 2006;355(22):2283-2296. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17135583](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17135583).

# Initiation of Antiretroviral Therapy (Last updated January 28, 2016; last reviewed January 28, 2016)

## Panel's Recommendations

- Antiretroviral therapy (ART) is recommended for all HIV-infected individuals, regardless of CD4 T lymphocyte cell count, to reduce the morbidity and mortality associated with HIV infection (**AI**).
- ART is also recommended for HIV-infected individuals to prevent HIV transmission (**AI**).
- When initiating ART, it is important to educate patients regarding the benefits and considerations regarding ART, and to address strategies to optimize adherence. On a case-by-case basis, ART may be deferred because of clinical and/or psychosocial factors, but therapy should be initiated as soon as possible.

**Rating of Recommendations:** A = Strong; B = Moderate; C = Optional

**Rating of Evidence:** I = Data from randomized controlled trials; II = Data from well-designed nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion

## Introduction

Without antiretroviral therapy (ART), most HIV-infected individuals will eventually develop progressive immunodeficiency marked by CD4 T lymphocyte (CD4) cell depletion and leading to AIDS-defining illnesses and premature death. The primary goal of ART is to prevent HIV-associated morbidity and mortality. This goal is best accomplished by using effective ART to maximally inhibit HIV replication to sustain plasma HIV-1 RNA (viral load) below limits of quantification by commercially available assays. Durable viral suppression improves immune function and overall quality of life, lowers the risk of both AIDS-defining and non-AIDS-defining complications, and prolongs life.

Furthermore, high plasma HIV-1 RNA is a major risk factor for HIV transmission, and effective ART can reduce viremia and transmission of HIV to sexual partners by more than 96%.<sup>1,2</sup> Modelling studies suggest that expanded use of ART may lower incidence and, eventually, prevalence of HIV on a community or population level.<sup>3</sup> Thus, a secondary goal of ART is to reduce the risk of HIV transmission.

Historically, HIV-infected individuals have had low CD4 counts at presentation to care.<sup>4</sup> However, there have been concerted efforts to increase testing of at-risk individuals and to link HIV-infected individuals to medical care before they have advanced HIV disease. Deferring ART until CD4 counts decline puts HIV-infected individuals at risk of AIDS-defining and certain serious non-AIDS conditions. Furthermore, the magnitude of CD4 recovery is directly correlated with CD4 count at ART initiation. Consequently, many individuals who start treatment with CD4 counts <350 cells/mm<sup>3</sup> never achieve CD4 counts >500 cells/mm<sup>3</sup> after up to 6 years on ART<sup>5</sup> and have a shorter life expectancy than those initiating therapy at higher CD4 count thresholds.<sup>5,6</sup>

For the above reasons, since 2012, the Panel on Antiretroviral Guidelines for Adults and Adolescents (the Panel) has recommended initiating ART in all HIV-infected individuals; however, based on published evidence available at the time, the strength of the recommendation has differed by CD4 count strata (**AI** for CD4 count <350 cells/mm<sup>3</sup>, **AII** for CD4 count between 350 and 500 cells/mm<sup>3</sup>, and **BIII** for CD4 count >500 cells/mm<sup>3</sup>). However, findings from two large, randomized controlled trials that addressed the optimal time to initiate ART—START (Strategic Timing of Antiretroviral Therapy)<sup>7</sup> and TEMPRANO<sup>8</sup>—have led the Panel to increase the strength and evidence rating of this recommendation to **AI** for all patients, regardless of CD4 cell count. Both studies demonstrated about a 50% reduction in morbidity and mortality among HIV-infected individuals with CD4 counts >500 cells/mm<sup>3</sup> randomized to receive ART immediately versus delaying initiation of ART (described in more detail below). Prompt initiation of ART is particularly important for patients with certain clinical conditions, as discussed below.

The decision to initiate ART should always include consideration of a patient's comorbid conditions and his



or her willingness and readiness to initiate therapy. Thus, on a case-by-case basis, ART may be deferred because of clinical and/or psychosocial factors; however, therapy should be initiated as soon as possible.

## Panel's Recommendations

ART is recommended for all HIV-infected individuals, regardless of CD4 cell count, to reduce the morbidity and mortality associated with HIV infection (AI). ART is also recommended for HIV-infected individuals to prevent HIV transmission (AI). When initiating ART, it is important to educate patients about the benefits of ART, and to address barriers to adherence and recommend strategies to optimize adherence. On a case-by-case basis, ART may be deferred because of clinical and/or psychosocial factors; however, therapy should be initiated as soon as possible. Patients should also understand that currently available ART does not cure HIV. To improve and maintain immunologic function and maintain viral suppression, ART should be continued indefinitely.

While ART is recommended for all patients, the following conditions increase the urgency to initiate therapy:

- Pregnancy (refer to the [Perinatal Guidelines](#) for more detailed recommendations on the management of HIV-infected pregnant women)<sup>9</sup>
- AIDS-defining conditions, including HIV-associated dementia (HAD) and AIDS-associated malignancies
- Acute opportunistic infections (OIs) (see discussion below)
- Lower CD4 counts (e.g., <200 cells/mm<sup>3</sup>)
- HIV-associated nephropathy (HIVAN)
- Acute/early infection (see discussion in the [Acute/Early Infection](#) section)
- HIV/hepatitis B virus coinfection
- HIV/hepatitis C virus coinfection

## Acute Opportunistic Infections and Malignancies

In patients who have AIDS-associated opportunistic diseases for which there is no effective therapy (e.g., cryptosporidiosis, microsporidiosis, progressive multifocal leukoencephalopathy), improvement of immune function with ART may improve disease outcomes, thus ART should be started as soon as possible. For patients with mild to moderate cutaneous Kaposi's sarcoma (KS), prompt initiation of ART alone without chemotherapy has been associated with improvement of the KS lesions, even though initial transient progression of KS lesions as a manifestation of immune reconstitution inflammatory syndrome (IRIS) can also occur.<sup>10</sup> Similarly, although an IRIS-like presentation of non-Hodgkins lymphoma after initiation of ART has been described,<sup>11</sup> greater ART-mediated viral suppression is also associated with longer survival among individuals undergoing treatment for AIDS lymphoma.<sup>12</sup> Drug interactions should be considered when selecting ART given the potential for significant interactions between chemotherapeutic agents and some ARV drugs (particularly some nucleoside reverse transcriptase inhibitor [NNRTI] and ritonavir- or cobicistat-boosted regimens). However, a diagnosed malignancy should not delay initiation of ART nor should initiation of ART delay treatment for the malignancy.

In the setting of some OIs, such as cryptococcal and tuberculous meningitis, for which immediate therapy may increase the risk of serious IRIS, a short delay before initiating ART may be warranted.<sup>13-16</sup> When ART is initiated in a patient with an intracranial infection, the patient should be closely monitored for signs and symptoms associated with IRIS. In the setting of other OIs, such as *Pneumocystis jirovecii* pneumonia, early initiation of ART is associated with increased survival;<sup>17</sup> therefore, therapy should not be delayed.

In patients who have active non-meningeal tuberculosis, initiating ART during treatment for tuberculosis confers a significant survival advantage;<sup>18-22</sup> therefore, ART should be initiated as recommended in [Mycobacterium Tuberculosis Disease with HIV Coinfection](#).

Clinicians should refer to the [Guidelines for Prevention and Treatment of Opportunistic Infections in HIV-Infected Adults and Adolescents](#)<sup>10</sup> for more detailed discussion on when to initiate ART in the setting of a specific OI.

### ***The Need for Early Diagnosis of HIV***

Fundamental to the earlier initiation of ART recommended in these guidelines is the assumption that patients will be diagnosed early in the course of HIV infection. Unfortunately, some patients with HIV infections are still diagnosed at later stages of disease. Despite the recommendations for routine, opt-out HIV screening in the health care setting regardless of perceptions about a patient's risk of infection<sup>23</sup> and the gradual increase in CD4 counts at first presentation to care, the median CD4 count of newly diagnosed patients remains below 350 cells/mm<sup>3</sup>.<sup>4</sup> Diagnosis of HIV infection is delayed more often in nonwhites, injection drug users, and older adults than in other populations, and many individuals in these groups develop AIDS-defining illnesses within 1 year of diagnosis.<sup>24-26</sup> Therefore, to ensure that the current treatment guidelines have maximum impact, routine HIV screening per current Centers for Disease Control and Prevention recommendations is essential. It is also critical that all newly diagnosed patients are educated about HIV disease and linked to care for full evaluation, follow-up, and management. Once patients are in care, focused effort is required to retain them in the health care system so that both the infected individuals and their sexual partners can fully benefit from early diagnosis and treatment.

### **Evidence Supporting Benefits of ART to Prevent Morbidity and Mortality**

Although observational studies had been inconsistent in defining the optimal time to initiate ART,<sup>27-30</sup> randomized controlled trials now definitively demonstrate that ART should be initiated in all HIV-infected patients, regardless of disease stage. The urgency to initiate ART is greatest for patients at lower CD4 counts, where the absolute risk of OIs, non-AIDS morbidity, and death is highest. Randomized controlled trials have long shown that ART improves survival and delays disease progression in patients with CD4 counts <200 cells/mm<sup>3</sup> and/or history of AIDS-defining conditions.<sup>17,31</sup> Additionally, a randomized controlled trial conducted in Haiti showed that patients who started ART with CD4 counts between 200 to 350 cells/mm<sup>3</sup> survived longer than those who deferred ART until their CD4 counts fell below 200 cells/mm<sup>3</sup>.<sup>32</sup> Most recently, the published START and TEMPRANO trials provide the evidence for the Panel's recommendation to initiate ART in all patients regardless of CD4 cell count (AI). The results of these two studies are summarized below.

The START trial is a large, multi-national, randomized controlled clinical trial designed to evaluate the role of early ART in asymptomatic HIV-infected patients in reducing a composite clinical endpoint of AIDS-defining illnesses, serious non-AIDS events, or death. In this study, ART-naïve adults (aged >18 years) with CD4 counts >500 cells/mm<sup>3</sup> were randomized to initiate ART soon after randomization (immediate-initiation arm) or to wait to initiate ART until their CD4 counts declined to <350 cells/mm<sup>3</sup> or until they developed a clinical indication for therapy (deferred-initiation arm). The study enrolled 4,685 participants, with a mean follow-up of 3 years. When the randomized arms of the study were closed, the primary endpoint of serious AIDS or non-AIDS events was reported in 42 participants (1.8%, or 0.60 events/100 person-years) in the early ART arm and 96 participants (4.1%, or 1.38 events/100 person-years) in the deferred ART arm (hazard ratio [HR] 0.43, favoring early ART [95% confidence interval (CI), 0.30–0.62,  $P < .001$ ]). The most common clinical events reported were tuberculosis and AIDS and non-AIDS malignancies. The majority (59%) of clinical events in the delayed ART arm occurred in participants whose CD4 counts were still above 500 cells/mm<sup>3</sup>, evidence for a benefit of immediate ART even before CD4 count declines below this threshold. Furthermore, the benefit of immediate ART was evident across all participant subgroups examined including men and women, older and younger participants, individuals with high and low plasma HIV RNA levels, and participants living in high-income and low/middle-income countries. Although START was not sufficiently powered to examine the benefit of immediate ART for each category of clinical events, the benefit of immediate ART appeared to be particularly strong for AIDS events (HR 0.28, [95% CI, 0.15–0.50,  $P <$



.001]), tuberculosis (HR 0.29, [95% CI, 0.12–0.73,  $P = .008$ ]), and malignancies (HR 0.36, [95% CI, 0.19 to 0.66;  $P = .001$ ]). Importantly, immediate ART also significantly reduced the rate of pooled serious non-AIDS events (HR 0.61, [95% CI, 0.38–0.97,  $P = 0.04$ ]).<sup>7</sup>

The TEMPRANO ANRS 12136 study was a randomized controlled trial conducted in Cote d'Ivoire. Using a two-by-two factorial design, HIV-infected participants with CD4 counts  $<800$  cells/mm<sup>3</sup> were randomized to either immediate ART or deferred ART (based on the national guidelines criteria for starting treatment); half of the participants in each group received isoniazid for prevention of tuberculosis for 6 months and half did not. The primary study endpoint was a combination of all-cause deaths, AIDS diseases, non-AIDS malignancies, and non-AIDS invasive bacterial diseases. More than 2,000 participants enrolled in the trial, with a median follow-up of 30 months. Among the 849 participants who had baseline CD4 counts  $>500$  cells/mm<sup>3</sup>, 68 primary outcome events were reported in 61 patients. The risk of primary events was lower with immediate ART than with deferred ART, with a hazard ratio of 0.56 in favor of early ART (CI, 0.33–0.94). On the basis of these results, the study team concluded that early ART is beneficial in reducing the rate of these clinical events.<sup>8</sup>

The TEMPRANO and START trials had very similar estimates of the protective effect of immediate ART among HIV-infected individuals with CD4 counts  $>500$  cells/mm<sup>3</sup>, further strengthening the Panel's recommendation that ART be initiated in all patients regardless of CD4 cell count.

### ***Theoretical Continued Benefit of Early ART Initiation Long After Viral Suppression is Achieved***

While the START and TEMPRANO studies demonstrated a clear benefit of immediate ART initiation in individuals with CD4 cell counts  $>500$  cells/mm<sup>3</sup>, it is plausible that the benefits of early ART initiation continue long after viral suppression is achieved. As detailed in the Poor CD4 Cell Recovery and Persistent Inflammation section, persistently low CD4 counts and abnormally high levels of immune activation and inflammation despite suppressive ART predict an increased risk of not only AIDS events, but also non-AIDS events including kidney disease, liver disease, cardiovascular disease, neurologic complications, and malignancies. Earlier ART initiation appears to increase the probability of restoring normal CD4 counts, a normal CD4/CD8 ratio, and lower levels of immune activation and inflammation.<sup>33–38</sup> Individuals initiating ART very early (i.e., during the first 6 months after infection) also appear to achieve lower immune activation levels and better immune function (as assessed by vaccine responsiveness) during ART-mediated viral suppression than those who delay therapy for a few years or more.<sup>39–41</sup> Thus, while these questions have yet to be addressed in definitive randomized controlled trials, earlier ART initiation may result in less residual immune dysfunction during treatment, which theoretically may result in reduced risk of disease for decades to come.

## **Evidence Supporting the Use of ART to Prevent HIV Transmission**

### ***Prevention of Sexual Transmission***

A number of investigations, including biological, ecological, and epidemiological studies and one randomized clinical trial, provide strong evidence that treatment of the HIV-infected individual can significantly reduce sexual transmission of HIV. Lower plasma HIV RNA levels are associated with decreases in the concentration of the virus in genital secretions.<sup>42,43</sup> Studies of HIV-serodiscordant heterosexual couples have demonstrated a relationship between level of plasma viremia and risk of HIV transmission—when plasma HIV RNA levels are lower, transmission events are less common.<sup>1,44</sup>

Most significantly, the multi-continental HPTN 052 trial enrolled 1,763 HIV-serodiscordant couples in which the HIV-infected partner was ART naive with a CD4 count of 350 to 550 cells/mm<sup>3</sup> at enrollment to compare the effect of immediate ART versus delayed therapy (not started until CD4 count  $<250$  cells/mm<sup>3</sup>) on HIV transmission to the HIV-uninfected partner.<sup>2</sup> At study entry, 97% of the participants reported to be in a

heterosexual monogamous relationship. All study participants were counseled on behavioral modification and condom use. The interim results reported 28 linked HIV transmission events during the study period, with only 1 event in the early therapy arm. This 96% reduction in transmission associated with early ART was statistically significant (HR 0.04; 95% CI, 0.01–0.27;  $P < 0.001$ ). The final results of this study showed a sustained 93% reduction of HIV transmission within couples when the HIV-infected partner was taking ART as prescribed and viral load was suppressed.<sup>45</sup> Notably, there were only eight cases of HIV transmission within couples after the HIV-infected partner started ART; four transmissions occurred before the HIV-infected partner was virologically suppressed and four other transmissions occurred during virologic failure. These results provide evidence that suppressive ART is more effective at preventing transmission of HIV than all other behavioral and biomedical prevention interventions studied. This study, as well as other observational studies and modeling analyses showing a decreased rate of HIV transmission among serodiscordant heterosexual couples following the introduction of ART, demonstrates that suppression of viremia in ART-adherent patients with no concomitant sexually transmitted diseases (STDs) substantially reduces the risk of HIV transmission.<sup>3,46–49</sup> HPTN 052 was conducted in heterosexual couples and not in populations at risk of HIV transmission via male-to-male sexual contact or needle sharing. In addition, in this clinical trial, adherence to ART was excellent. However, the prevention benefits of effective ART observed in HPTN 052 can reasonably be presumed to apply broadly. Therefore, the Panel recommends that ART be offered to individuals who are at risk of transmitting HIV to sexual partners **(AI)**. Clinicians should discuss with patients the potential individual and public health benefits of therapy and the need for adherence to the prescribed regimen. Clinicians should also stress that ART is not a substitute for condom use and behavioral modification and that ART does not protect against other STDs (see [Preventing Secondary Transmission of HIV](#)).

### ***Prevention of Perinatal Transmission***

As noted above, effective ART reduces transmission of HIV. The most dramatic and well-established example of this effect is the use of ART in pregnant women to prevent perinatal transmission of HIV. Effective suppression of HIV replication is a key determinant in reducing perinatal transmission. In the setting of maternal viral load suppressed to <50 copies/mL near delivery, use of combination ART during pregnancy has reduced the rate of perinatal transmission of HIV from approximately 20% to 30% to 0.1% to 0.5%.<sup>50,51</sup> ART is thus recommended for all HIV-infected pregnant women, for both maternal health and for prevention of HIV transmission to the newborn. In ART-naïve pregnant women ART should be initiated as soon as possible, with the goal of suppressing plasma viremia throughout pregnancy (see [Perinatal Guidelines](#)).

### **Considerations When Initiating ART**

ART regimens for treatment-naïve patients currently recommended in this guideline (see [What to Start](#)) can suppress and sustain viral loads below the level of quantification in most patients who adhere to their regimens. Most of the recommended regimens have low pill burden and are well tolerated. Once started on treatment, patients must continue ART indefinitely.

### ***Optimizing Adherence and Retention in Care***

The key to successful ART in maintaining viral suppression is adherence to the prescribed regimen. Treatment failure and resultant emergence of drug resistance mutations may compromise future treatment options. While optimizing adherence and linkage to care are critical regardless of the timing of ART initiation, the evidence thus far indicates that drug resistance occurs more frequently in individuals who initiate therapy later in the course of infection than in those who initiate ART earlier.<sup>52</sup> In both the START<sup>7</sup> and TEMPRANO<sup>8</sup> trials, participants randomized to immediate ART achieved higher rates of viral suppression than those randomized to delayed ART. Nevertheless, it is important to discuss strategies to optimize adherence and retention in care with patients before ART initiation. ART initiation may need to be briefly delayed to resolve issues identified during such discussions.

Several clinical, behavioral, and social factors have been associated with poor adherence. These factors include untreated major psychiatric disorders, neurocognitive impairment, active substance abuse, unstable housing, other unfavorable social circumstances, patient concerns about side effects, and poor adherence to clinic visits. Clinicians should identify areas where additional intervention is needed to improve adherence both before and after initiation of therapy. Some strategies to improve adherence are discussed in [Adherence to Antiretroviral Therapy](#). ART reduces morbidity and mortality even in patients with relatively poor adherence and established drug resistance. Thus, mental illness, substance abuse, and psychosocial challenges are not reasons to withhold ART from a patient. Rather, these issues indicate the need for additional interventions to support adherence and possibly the type of ART regimen to recommend (see [What to Start](#) section).

## Considerations for Special Populations

### *Elite HIV Controllers*

A small subset of HIV-infected individuals maintains plasma HIV-1 RNA levels below level of quantification for years without ART. These individuals are often referred to as “elite HIV controllers.”<sup>53,54</sup> There are limited data on the role of ART in these individuals. Given the clear benefit of ART regardless of CD4 count from the START and TEMPRANO studies, delaying ART to see if a patient becomes an elite controller after initial diagnosis is strongly discouraged. Nevertheless, significant uncertainty remains about the optimal management of elite controllers who have maintained undetectable viremia in the absence of ART for years.

Given that ongoing HIV replication occurs even in elite controllers, ART is clearly recommended for controllers with evidence of HIV disease progression, as defined by declining CD4 counts or development of HIV-related complications. Nonetheless, even elite controllers with normal CD4 counts also have evidence of abnormally high immune activation and surrogate markers of atherosclerosis, which may contribute to an increased risk of non-AIDS related diseases.<sup>53,55-57</sup> One observational study suggests that elite controllers are hospitalized more often for cardiovascular and respiratory disease than patients from the general population and ART-treated patients.<sup>58</sup> Moreover, elite controllers with preserved CD4 counts appear to experience a decline in immune activation after ART initiation, suggesting that treatment may be beneficial.<sup>59</sup> Whether this potential immunologic benefit of ART in elite controllers outweighs potential ART toxicity and results in clinical benefit is unclear. Unfortunately, randomized controlled trials to address this question are unlikely given the very low prevalence of elite controllers. Although the START study included a number of participants with very low viral loads and demonstrated the benefit of immediate ART regardless of the extent of viremia, the study did not include a sufficient number of controllers to definitively determine the clinical impact of ART in this specific population. Nevertheless, there is a clear theoretical rationale for prescribing ART to HIV controllers even in the absence of detectable plasma HIV RNA levels. If ART is withheld, elite controllers should be followed closely, as some may experience CD4 cell decline, loss of viral control, or complications related to HIV infection.

### *HIV-Infected Adolescents*

Neither the START trial nor the TEMPRANO trial included adolescents. The Panel’s recommendation to initiate ART in all patients is extrapolated to adolescents based on the expectation that they will derive benefits from early ART similar to those observed in adults. Historically, compared to adults, youth have demonstrated significantly lower levels of ART adherence and viral suppression, and higher rates of viral rebound following initial viral suppression.<sup>60</sup> Because youth often face multiple psychosocial and other barriers to adherence, their ability to adhere to therapy should be carefully considered when making decisions about ART initiation. Although some adolescents may not be ready to initiate therapy, clinicians should offer ART while providing effective interventions to assess and address barriers to accepting and adhering to therapy. To optimize the benefits of ART for youth, a multidisciplinary care team should provide psychosocial and adherence support (see [HIV-Infected Adolescents](#) section).<sup>61</sup>

## Conclusion

The results of definitive randomized controlled trials support the Panel's recommendation to initiate ART to all HIV-infected individuals, regardless of CD4 cell count. Early diagnosis of HIV infection, followed by prompt ART initiation, has clear clinical benefits in reducing morbidity and mortality for HIV-infected patients and decreasing HIV transmission to their sexual partners. Although there are certain clinical and psychosocial factors that may occasionally necessitate a brief delay in ART, ART should be started as soon as possible. Clinicians should educate patients on the benefits and risks of ART and the importance of adherence.

## References

1. Quinn TC, Wawer MJ, Sewankambo N, et al. Viral load and heterosexual transmission of human immunodeficiency virus type 1. Rakai Project Study Group. *N Engl J Med*. Mar 30 2000;342(13):921-929. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=10738050](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=10738050).
2. Cohen MS, Chen YQ, McCauley M, et al. Prevention of HIV-1 infection with early antiretroviral therapy. *N Engl J Med*. Aug 11 2011;365(6):493-505. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=21767103](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=21767103).
3. Granich RM, Gilks CF, Dye C, De Cock KM, Williams BG. Universal voluntary HIV testing with immediate antiretroviral therapy as a strategy for elimination of HIV transmission: a mathematical model. *Lancet*. Jan 3 2009;373(9657):48-57. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19038438](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19038438).
4. Althoff KN, Gange SJ, Klein MB, et al. Late presentation for human immunodeficiency virus care in the United States and Canada. *Clin Infect Dis*. Jun 1 2010;50(11):1512-1520. Available at <http://www.ncbi.nlm.nih.gov/pubmed/20415573>.
5. Moore RD, Keruly JC. CD4+ cell count 6 years after commencement of highly active antiretroviral therapy in persons with sustained virologic suppression. *Clin Infect Dis*. Feb 1 2007;44(3):441-446. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17205456](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17205456).
6. Samji H, Cescon A, Hogg RS, et al. Closing the gap: increases in life expectancy among treated HIV-positive individuals in the United States and Canada. *PLoS One*. 2013;8(12):e81355. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24367482>.
7. INSIGHT START Study Group. Initiation of antiretroviral therapy in early asymptomatic HIV infection. *N Engl J Med*. Jul 20 2015. Available at <http://www.ncbi.nlm.nih.gov/pubmed/26192873>.
8. TEMPRANO ANRS Study Group, Danel C, Moh R, et al. A Trial of Early Antiretrovirals and Isoniazid Preventive Therapy in Africa. *N Engl J Med*. Aug 27 2015;373(9):808-822. Available at <http://www.ncbi.nlm.nih.gov/pubmed/26193126>.
9. Panel on Treatment of HIV-Infected Pregnant Women and Prevention of Perinatal Transmission. Recommendations for use of antiretroviral drugs in pregnant HIV-1-infected women for maternal health and interventions to reduce perinatal HIV transmission in the United States. 2014. Available at <http://aidsinfo.nih.gov/contentfiles/lvguidelines/PerinatalGL.pdf>. Accessed January 12, 2016.
10. Panel on Opportunistic Infections in HIV-Infected Adults and Adolescents. Guidelines for the prevention and treatment of opportunistic infections in HIV-infected adults and adolescents: recommendations from the Centers for Disease Control and Prevention, the National Institutes of Health, and the HIV Medicine Association of the Infectious Diseases Society of America. 2014. Available at [http://aidsinfo.nih.gov/contentfiles/lvguidelines/adult\\_oi.pdf](http://aidsinfo.nih.gov/contentfiles/lvguidelines/adult_oi.pdf). Accessed January 12, 2016.
11. Gopal S, Patel MR, Achenbach CJ, et al. Lymphoma immune reconstitution inflammatory syndrome in the center for AIDS research network of integrated clinical systems cohort. *Clin Infect Dis*. Jul 15 2014;59(2):279-286. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24755860>.
12. Gopal S, Patel MR, Yanik EL, et al. Association of early HIV viremia with mortality after HIV-associated lymphoma. *AIDS*. Sep 24 2013;27(15):2365-2373. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23736149>.
13. Torok ME, Yen NT, Chau TT, et al. Timing of initiation of antiretroviral therapy in human immunodeficiency virus (HIV)-associated tuberculous meningitis. *Clin Infect Dis*. Jun 2011;52(11):1374-1383. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=21596680](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=21596680).
14. Boulware DR, Meya DB, Muzoora C, et al. Timing of antiretroviral therapy after diagnosis of cryptococcal meningitis. *N*



15. Phillips P, Bonner S, Gataric N, et al. Nontuberculous mycobacterial immune reconstitution syndrome in HIV-infected patients: spectrum of disease and long-term follow-up. *Clin Infect Dis.* Nov 15 2005;41(10):1483-1497. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=16231262](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16231262).
16. Bicanic T, Meintjes G, Rebe K, et al. Immune reconstitution inflammatory syndrome in HIV-associated cryptococcal meningitis: a prospective study. *J Acquir Immune Defic Syndr.* Jun 1 2009;51(2):130-134. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19365271](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19365271).
17. Zolopa A, Andersen J, Powderly W, et al. Early antiretroviral therapy reduces AIDS progression/death in individuals with acute opportunistic infections: a multicenter randomized strategy trial. *PLoS One.* 2009;4(5):e5575. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19440326](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19440326).
18. Velasco M, Castilla V, Sanz J, et al. Effect of simultaneous use of highly active antiretroviral therapy on survival of HIV patients with tuberculosis. *J Acquir Immune Defic Syndr.* Feb 1 2009;50(2):148-152. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19131895](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19131895).
19. Abdool Karim SS, Naidoo K, Grobler A, et al. Timing of initiation of antiretroviral drugs during tuberculosis therapy. *N Engl J Med.* Feb 25 2010;362(8):697-706. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=20181971](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20181971).
20. Abdool Karim SS, Naidoo K, Grobler A, et al. Integration of antiretroviral therapy with tuberculosis treatment. *N Engl J Med.* Oct 20 2011;365(16):1492-1501. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=22010915](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=22010915).
21. Blanc FX, Sok T, Laureillard D, et al. Earlier versus later start of antiretroviral therapy in HIV-infected adults with tuberculosis. *N Engl J Med.* Oct 20 2011;365(16):1471-1481. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=22010913](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=22010913).
22. Havlir DV, Kendall MA, Ive P, et al. Timing of antiretroviral therapy for HIV-1 infection and tuberculosis. *N Engl J Med.* Oct 20 2011;365(16):1482-1491. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=22010914](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=22010914).
23. Branson BM, Handsfield HH, Lampe MA, et al. Revised recommendations for HIV testing of adults, adolescents, and pregnant women in health-care settings. *MMWR Recomm Rep.* Sep 22 2006;55(RR-14):1-17. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=16988643](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16988643).
24. Wolbers M, Bucher HC, Furrer H, et al. Delayed diagnosis of HIV infection and late initiation of antiretroviral therapy in the Swiss HIV Cohort Study. *HIV Med.* Jul 2008;9(6):397-405. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18410354](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18410354).
25. Centers for Disease Control and Prevention. Late HIV testing—34 states, 1996–2005. *MMWR Morb Mortal Wkly Rep.* Jun 26 2009;58(24):661-665. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19553901](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19553901).
26. Grigoryan A, Hall HI, Durant T, Wei X. Late HIV diagnosis and determinants of progression to AIDS or death after HIV diagnosis among injection drug users, 33 US States, 1996–2004. *PLoS One.* 2009;4(2):e4445. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19214229](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19214229).
27. Kitahata MM, Gange SJ, Abraham AG, et al. Effect of early versus deferred antiretroviral therapy for HIV on survival. *N Engl J Med.* Apr 30 2009;360(18):1815-1826. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19339714](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19339714).
28. Sterne JA, May M, Costagliola D, et al. Timing of initiation of antiretroviral therapy in AIDS-free HIV-1-infected patients: a collaborative analysis of 18 HIV cohort studies. *Lancet.* Apr 18 2009;373(9672):1352-1363. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19361855](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19361855).
29. CASCADE Collaboration. Timing of HAART initiation and clinical outcomes in human immunodeficiency virus type 1 seroconverters. *Arch Intern Med.* Sep 26 2011;171(17):1560-1569. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=21949165](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=21949165).
30. Cain LE, Logan R, Robins JM, et al. When to initiate combined antiretroviral therapy to reduce mortality and AIDS-defining illness in HIV-infected persons in developed countries: an observational study. *Ann Intern Med.* Apr 19 2011;154(8):509-515. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=21502648](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=21502648).
31. Hammer SM, Squires KE, Hughes MD, et al. A controlled trial of two nucleoside analogues plus indinavir in persons with human immunodeficiency virus infection and CD4 cell counts of 200 per cubic millimeter or less. AIDS Clinical

- Trials Group 320 Study Team. *N Engl J Med*. Sep 11 1997;337(11):725-733. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=9287227](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=9287227).
32. Severe P, Juste MA, Ambroise A, et al. Early versus standard antiretroviral therapy for HIV-infected adults in Haiti. *N Engl J Med*. Jul 15 2010;363(3):257-265. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=20647201](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20647201).
  33. Le T, Wright EJ, Smith DM, et al. Enhanced CD4+ T-cell recovery with earlier HIV-1 antiretroviral therapy. *N Engl J Med*. Jan 17 2013;368(3):218-230. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23323898>.
  34. Hunt PW, Martin JN, Sinclair E, et al. T cell activation is associated with lower CD4+ T cell gains in human immunodeficiency virus-infected patients with sustained viral suppression during antiretroviral therapy. *J Infect Dis*. May 15 2003;187(10):1534-1543. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=12721933](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=12721933).
  35. Mocroft A, Phillips AN, Gatell J, et al. Normalisation of CD4 counts in patients with HIV-1 infection and maximum virological suppression who are taking combination antiretroviral therapy: an observational cohort study. *Lancet*. Aug 4 2007;370(9585):407-413. Available at <http://www.ncbi.nlm.nih.gov/pubmed/17659333>.
  36. Kelley CF, Kitchen CM, Hunt PW, et al. Incomplete peripheral CD4+ cell count restoration in HIV-infected patients receiving long-term antiretroviral treatment. *Clin Infect Dis*. Mar 15 2009;48(6):787-794. Available at <http://www.ncbi.nlm.nih.gov/pubmed/19193107>.
  37. Lange CG, Lederman MM, Medvik K, et al. Nadir CD4+ T-cell count and numbers of CD28+ CD4+ T-cells predict functional responses to immunizations in chronic HIV-1 infection. *AIDS*. Sep 26 2003;17(14):2015-2023. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=14502004](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=14502004).
  38. Robbins GK, Spritzler JG, Chan ES, et al. Incomplete reconstitution of T cell subsets on combination antiretroviral therapy in the AIDS Clinical Trials Group protocol 384. *Clin Infect Dis*. Feb 1 2009;48(3):350-361. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19123865](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19123865).
  39. Jain V, Hartogensis W, Bacchetti P, et al. Antiretroviral therapy initiated within 6 months of HIV infection is associated with lower T-cell activation and smaller HIV reservoir size. *J Infect Dis*. Oct 15 2013;208(8):1202-1211. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23852127>.
  40. Burdo TH, Lentz MR, Autissier P, et al. Soluble CD163 made by monocyte/macrophages is a novel marker of HIV activity in early and chronic infection prior to and after anti-retroviral therapy. *J Infect Dis*. Jul 1 2011;204(1):154-163. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21628670>.
  41. Okulicz JF, Le TD, Agan BK, et al. Influence of the timing of antiretroviral therapy on the potential for normalization of immune status in human immunodeficiency virus 1-infected individuals. *JAMA Intern Med*. Jan 2015;175(1):88-99. Available at <http://www.ncbi.nlm.nih.gov/pubmed/25419650>.
  42. Vernazza PL, Troiani L, Flepp MJ, et al. Potent antiretroviral treatment of HIV-infection results in suppression of the seminal shedding of HIV. The Swiss HIV Cohort Study. *AIDS*. Jan 28 2000;14(2):117-121. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=10708281](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=10708281).
  43. Coombs RW, Reichelderfer PS, Landay AL. Recent observations on HIV type-1 infection in the genital tract of men and women. *AIDS*. Mar 7 2003;17(4):455-480. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=12598766](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=12598766).
  44. Tovanabutra S, Robison V, Wongtrakul J, et al. Male viral load and heterosexual transmission of HIV-1 subtype E in northern Thailand. *J Acquir Immune Defic Syndr*. Mar 1 2002;29(3):275-283. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=11873077](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11873077).
  45. Cohen M, HPTN 052 Study Team. Antiretroviral treatment prevents HIV transmission: final results from the HPTN 052 randomized controlled trial. Presented at: 8th IAS Conference on HIV Pathogenesis, Treatment, and Prevention. 2015. Vancouver, Canada.
  46. Castilla J, Del Romero J, Hernando V, Marinovich B, Garcia S, Rodriguez C. Effectiveness of highly active antiretroviral therapy in reducing heterosexual transmission of HIV. *J Acquir Immune Defic Syndr*. Sep 1 2005;40(1):96-101. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=16123689](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16123689).
  47. Bunnell R, Ekwaru JP, Solberg P, et al. Changes in sexual behavior and risk of HIV transmission after antiretroviral therapy and prevention interventions in rural Uganda. *AIDS*. Jan 2 2006;20(1):85-92. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=16327323](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16327323).
  48. Wilson DP, Law MG, Grulich AE, Cooper DA, Kaldor JM. Relation between HIV viral load and infectiousness: a

model-based analysis. *Lancet*. Jul 26 2008;372(9635):314-320. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18657710](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18657710).

49. Reynolds SJ, Makumbi F, Nakigozi G, et al. HIV-1 transmission among HIV-1 discordant couples before and after the introduction of antiretroviral therapy. *AIDS*. Feb 20 2011;25(4):473-477. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21160416>.
50. Tubiana R, Le Chenadec J, Rouzioux C, et al. Factors associated with mother-to-child transmission of HIV-1 despite a maternal viral load <500 copies/ml at delivery: a case-control study nested in the French perinatal cohort (EPF-ANRS CO1). *Clin Infect Dis*. Feb 15 2010;50(4):585-596. Available at <http://www.ncbi.nlm.nih.gov/pubmed/20070234>.
51. Townsend CL, Cortina-Borja M, Peckham CS, de Ruiter A, Lyall H, Tookey PA. Low rates of mother-to-child transmission of HIV following effective pregnancy interventions in the United Kingdom and Ireland, 2000-2006. *AIDS*. May 11 2008;22(8):973-981. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18453857](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18453857).
52. Uy J, Armon C, Buchacz K, Wood K, Brooks JT. Initiation of HAART at higher CD4 cell counts is associated with a lower frequency of antiretroviral drug resistance mutations at virologic failure. *J Acquir Immune Defic Syndr*. Aug 1 2009;51(4):450-453. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19474757](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19474757).
53. Hunt PW, Brenchley J, Sinclair E, et al. Relationship between T cell activation and CD4+ T cell count in HIV-seropositive individuals with undetectable plasma HIV RNA levels in the absence of therapy. *J Infect Dis*. Jan 1 2008;197(1):126-133. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18171295](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18171295).
54. Choudhary SK, Vrsekoop N, Jansen CA, et al. Low immune activation despite high levels of pathogenic human immunodeficiency virus type 1 results in long-term asymptomatic disease. *J Virol*. Aug 2007;81(16):8838-8842. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17537849](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17537849).
55. Pereyra F, Lo J, Triant VA, et al. Increased coronary atherosclerosis and immune activation in HIV-1 elite controllers. *AIDS*. Nov 28 2012;26(18):2409-2412. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23032411>.
56. Hsue PY, Hunt PW, Schnell A, et al. Role of viral replication, antiretroviral therapy, and immunodeficiency in HIV-associated atherosclerosis. *AIDS*. Jun 1 2009;23(9):1059-1067. Available at <http://www.ncbi.nlm.nih.gov/pubmed/19390417>.
57. Krishnan S, Wilson EM, Sheikh V, et al. Evidence for innate immune system activation in HIV type 1-infected elite controllers. *J Infect Dis*. Mar 2014;209(6):931-939. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24185941>.
58. Crowell TA, Gebo KA, Blankson JN, et al. Hospitalization Rates and Reasons Among HIV Elite Controllers and Persons With Medically Controlled HIV Infection. *J Infect Dis*. Jun 1 2015;211(11):1692-1702. Available at <http://www.ncbi.nlm.nih.gov/pubmed/25512624>.
59. Hatano H, Yukl SA, Ferre AL, et al. Prospective antiretroviral treatment of asymptomatic, HIV-1 infected controllers. *PLoS Pathog*. 2013;9(10):e1003691. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24130489>.
60. Ryscavage P, Anderson EJ, Sutton SH, Reddy S, Taiwo B. Clinical outcomes of adolescents and young adults in adult HIV care. *J Acquir Immune Defic Syndr*. Oct 1 2011;58(2):193-197. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21826014>.
61. Rudy BJ, Murphy DA, Harris DR, Muenz L, Ellen J, Adolescent Trials Network for HIVAI. Patient-related risks for nonadherence to antiretroviral therapy among HIV-infected youth in the United States: a study of prevalence and interactions. *AIDS Patient Care STDS*. Mar 2009;23(3):185-194. Available at <http://www.ncbi.nlm.nih.gov/pubmed/19866536>.



# What to Start: Initial Combination Regimens for the Antiretroviral-Naive Patient (Last updated January 28, 2016; last reviewed January 28, 2016)

On November 18, 2015, the U.S. Department of Health and Human Services' Panel on Antiretroviral Guidelines for Adults and Adolescents issued a statement regarding the inclusion of elvitegravir/cobicistat/tenofovir alafenamide/emtricitabine as a Recommended regimen for patients with pre-antiretroviral therapy CrCl  $\geq 30$  mL/min. An updated What to Start section with discussion regarding this regimen will be available in the next update of the Guidelines.

## Panel's Recommendations

- An antiretroviral regimen for a treatment-naive patient generally consists of two nucleoside reverse transcriptase inhibitors in combination with a third active antiretroviral drug from one of three drug classes: an integrase strand transfer inhibitor, a non-nucleoside reverse transcriptase inhibitor, or a protease inhibitor with a pharmacokinetic enhancer (cobicistat or ritonavir).
- The Panel classifies the following regimens as Recommended regimens for antiretroviral-naive patients:

### Integrase Strand Transfer Inhibitor-Based Regimens:

- Dolutegravir/abacavir/lamivudine<sup>a</sup>—**only** for patients who are HLA-B\*5701 negative (AI)
- Dolutegravir plus tenofovir disoproxil fumarate/emtricitabine<sup>a</sup> (AI)
- **Elvitegravir/cobicistat/tenofovir alafenamide/emtricitabine—only for patients with pre-antiretroviral therapy CrCl  $\geq 30$  mL/min (AI)**
- Elvitegravir/cobicistat/tenofovir disoproxil fumarate/emtricitabine—**only** for patients with pre-antiretroviral therapy CrCl  $> 70$  mL/min (AI)
- Raltegravir plus tenofovir/emtricitabine<sup>a</sup> (AI)

### Protease Inhibitor-Based Regimen:

- Darunavir/ritonavir plus tenofovir disoproxil fumarate/emtricitabine<sup>a</sup> (AI)
- On the basis of individual patient characteristics and needs, an Alternative regimen or, less frequently, an Other regimen may in some instances be the optimal regimen for a patient. A list of Alternative and Other regimens can be found in [Table 6](#).
- Given the large number of excellent options for initial therapy, selection of a regimen for a particular patient should be guided by factors such as virologic efficacy, toxicity, pill burden, dosing frequency, drug-drug interaction potential, resistance testing results, comorbid conditions, and cost. [Table 7](#) provides guidance on choosing an antiretroviral regimen based on selected clinical case scenarios. [Table 8](#) highlights the advantages and disadvantages of different components in a regimen.

**Rating of Recommendations:** A = Strong; B = Moderate; C = Optional

**Rating of Evidence:** I = Data from randomized controlled trials; II = Data from well-designed nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert Opinion

<sup>a</sup> Lamivudine may substitute for emtricitabine or vice versa.

## Introduction

More than 25 antiretroviral (ARV) drugs in 6 mechanistic classes are Food and Drug Administration (FDA) approved for treatment of HIV infection. These six classes include the nucleoside/nucleotide reverse transcriptase inhibitors (NRTIs), non-nucleoside reverse transcriptase inhibitors (NNRTIs), protease inhibitors (PIs), a fusion inhibitor (FI), a CCR5 antagonist, and integrase strand transfer inhibitors (INSTIs). In addition, two drugs (pharmacokinetic [PK] enhancers or boosters) are used solely to improve the pharmacokinetic profiles of some ARV drugs (e.g., PIs and the INSTI elvitegravir [EVG]).

The initial ARV regimen for a treatment-naive patient generally consists of two NRTIs, usually abacavir plus lamivudine (ABC/3TC) or tenofovir disoproxil fumarate plus emtricitabine (TDF/FTC), plus a drug from one of three drug classes: an INSTI, an NNRTI, or a PK-enhanced PI. As shown in clinical trials and by retrospective evaluation of cohorts of patients in clinical care, this strategy for initial treatment has resulted in HIV RNA decreases and CD4 T lymphocyte (CD4) cell increases in most patients.<sup>1-3</sup>

## ***Data Used for Making Recommendations***

The Panel on Antiretroviral Guidelines for Adults and Adolescents (the Panel)'s recommendations are primarily based on clinical trial data published in peer-reviewed journals and data prepared by manufacturers for FDA review. In select cases, the Panel considers data presented in abstract format at major scientific meetings. The Panel's first criterion for selection of evidence on which to base recommendations is published information from a randomized, prospective clinical trial with an adequate sample size that demonstrates that an ARV regimen has shown high rates of viral suppression, increased CD4 cell count, and has a favorable safety profile. Comparative clinical trials of initial treatments generally show no significant differences in HIV-related clinical endpoints or survival. Thus, assessment of regimen efficacy and safety are primarily based on surrogate marker endpoints (especially rates of HIV RNA suppression) and the incidence and severity of adverse events. When developing recommendations, the Panel also considers post-marketing safety data, observational cohort data published in peer-reviewed publications, and the experience of clinicians and community members who are actively engaged in patient care.

The Panel reviewed the available data to arrive at Recommended, Alternative, or Other regimens, as specified in [Table 6](#). Each of the regimens listed in [Table 6](#) has shown potent virologic efficacy as measured by the proportion of participants in comparative clinical trials able to achieve and maintain viral suppression. Recommended regimens are those studied in randomized controlled trials and shown to have optimal and durable virologic efficacy, favorable tolerability and toxicity profiles, and ease of use. Alternative regimens are those that are effective but have potential disadvantages, limitations for use in certain patient populations, or less supporting data than Recommended regimens. In certain situations, depending on individual patient characteristics and needs, an Alternative regimen may actually be the optimal regimen for a specific patient. Some regimens are classified as Other regimens because, compared with Recommended or Alternative regimens, they have reduced virologic activity, limited supporting data from large comparative clinical trials, or other factors such as greater toxicities, higher pill burden, drug interaction potential, or limitations for use in certain patient populations.

In addition to [Table 6](#), a number of tables presented below and at the end of the guidelines provide clinicians with guidance on selecting and prescribing an optimal regimen for an individual patient. [Table 7](#) lists specific case scenarios to guide regimen selection for patients with common clinical conditions. [Table 8](#) lists the potential advantages and disadvantages of the components used in Recommended and Alternative regimens. [Table 9](#) lists agents or regimens not recommended for initial treatment. [Appendix B, Tables 1–6](#) list characteristics of individual ARV agents, such as formulations, dosing recommendations, PKs, and common adverse effects. [Appendix B, Table 7](#) provides ARV dosing recommendations for patients who have renal or hepatic insufficiency.

## ***Changes Since the Last Revision of the Guidelines***

Since the last revision of these guidelines, new data from clinical trials and cohort studies, as well as experience in clinical practice, have prompted significant changes to the list of Recommended, Alternative, and Other regimens for treatment-naïve patients ([Table 6](#)). Among these changes, the following deserve emphasis:

- There are now five Recommended regimens for antiretroviral therapy (ART)-naïve patients: four INSTI-based regimens and one ritonavir-boosted PI (PI/r)-based regimen.
- Results from a large comparative clinical trial comparing atazanavir/ritonavir (ATV/r) plus TDF/FTC to darunavir/ritonavir (DRV/r) or raltegravir (RAL) plus TDF/FTC showed a greater rate of toxicities-related discontinuation in the ATV/r arm.<sup>4</sup> Therefore, ATV/r plus TDF/FTC has been moved from the Recommended to the Alternative category.
- The Panel has also moved EFV/TDF/FTC from the Recommended to the Alternative category because of concerns about the tolerability of efavirenz (EFV) in clinical trials and practice, especially the high rate of central nervous system (CNS) related toxicities, and a possible association with suicidality observed in one analysis of four clinical trials.<sup>5</sup>

- Regimens that were previously listed as Recommended for patients with baseline HIV RNA <100,000 copies/mL or CD4 count >200 cells/mm<sup>3</sup> are now in the Alternative or Other category, with the same caveat to limit their use to patients with the cited HIV RNA and CD4 levels.
- Two regimens that use fewer than two NRTIs (DRV/r plus RAL and lopinavir/ritonavir [LPV/r] plus 3TC) are listed among the Other regimens, with the caveat that their use be limited to patients who cannot take either TDF or ABC.
- Coformulations of ATV and DRV with the PK enhancer cobicistat (COBI) have been added to the Alternative regimen options.

**Table 6. Recommended, Alternative, and Other Antiretroviral Regimen Options for Treatment-Naïve Patients**

An ARV regimen generally consists of two NRTIs (one of which is FTC or 3TC) plus an INSTI, NNRTI, or PK-enhanced PI. Selection of a regimen should be individualized on the basis of virologic efficacy, potential adverse effects, pill burden, dosing frequency, drug-drug interaction potential, a patient's resistance test results and comorbid conditions, and cost. [Table 7](#) lists specific case scenarios to guide regimen selection for patients with common clinical conditions. For more detailed recommendations on ARV choices and dosing in HIV-infected pregnant women, refer to the latest perinatal guidelines available at <http://aidsinfo.nih.gov/guidelines>.

<b>Recommended Regimen Options</b> (Drug classes and regimens within each class are arranged in alphabetical order.)
<p><u>INSTI-Based Regimens:</u></p> <ul style="list-style-type: none"> <li>• DTG/ABC/3TC<sup>a</sup>—<b>only</b> for patients who are HLA-B*5701 negative (<b>A1</b>)</li> <li>• DTG plus TDF/FTC<sup>a</sup> (<b>A1</b>)</li> <li>• EVG/c/TAF/FTC—<b>only</b> for patients with pre-treatment estimated CrCl ≥30 mL/min (<b>A1</b>)</li> <li>• EVG/c/TDF/FTC—<b>only</b> for patients with pre-treatment estimated CrCl ≥70 mL/min (<b>A1</b>)</li> <li>• RAL plus TDF/FTC<sup>a</sup> (<b>A1</b>)</li> </ul> <p><u>PI-Based Regimens:</u></p> <ul style="list-style-type: none"> <li>• DRV/r plus TDF/FTC<sup>a</sup> (<b>A1</b>)</li> </ul>
<b>Alternative Regimen Options</b> (Drug classes and regimens within each class are arranged in alphabetical order.) Regimens that are effective and tolerable, but that have potential disadvantages when compared with the recommended regimens listed above, have limitations for use in certain patient populations, or have less supporting data from randomized clinical trials. <b>An alternative regimen may be the preferred regimen for some patients.</b>
<p><u>NNRTI-Based Regimens:</u></p> <ul style="list-style-type: none"> <li>• EFV/TDF/FTC<sup>a</sup> (<b>B1</b>)</li> <li>• RPV/TDF/FTC<sup>a</sup>—<b>only</b> for patients with pre-treatment HIV RNA &lt;100,000 copies/mL and CD4 cell count &gt;200 cells/mm<sup>3</sup> (<b>B1</b>)</li> </ul> <p><u>PI-Based Regimens:</u></p> <ul style="list-style-type: none"> <li>• ATV/c plus TDF/FTC<sup>a</sup>—<b>only</b> for patients with pre-treatment estimated CrCl ≥70 mL/min (<b>B1</b>)</li> <li>• ATV/r plus TDF/FTC<sup>a</sup> (<b>B1</b>)</li> <li>• (DRV/c or DRV/r) plus ABC/3TC<sup>a</sup>—<b>only</b> for patients who are HLA-B*5701 negative (<b>BIII</b> for DRV/c and <b>BII</b> for DRV/r)</li> <li>• DRV/c plus TDF/FTC<sup>a</sup>—<b>only</b> for patients with pre-treatment estimated CrCl ≥70 mL/min (<b>BII</b>)</li> </ul>

**Table 6. Recommended, Alternative, and Other Antiretroviral Regimen Options for Treatment-Naive Patients (page 2 of 2)**

<b>Other Regimen Options</b> (Drugs classes and regimens within each class are arranged in alphabetical order.) Regimens that, in comparison with Recommended and Alternative regimens, may have reduced virologic activity, limited supporting data from large comparative clinical trials, or other factors such as greater toxicities, higher pill burden, drug interaction potential, or limitations for use in certain patient populations.
<p><b>INSTI-Based Regimen</b></p> <ul style="list-style-type: none"> <li>• RAL plus ABC/3TC<sup>a</sup>—<b>only</b> for patients who are HLA-B*5701 negative (<b>CII</b>)</li> </ul> <p><b>NNRTI-Based Regimen:</b></p> <ul style="list-style-type: none"> <li>• EFV plus ABC/3TC<sup>a</sup>—<b>only</b> for patients who are HLA-B*5701 negative and with pre-treatment HIV RNA &lt;100,000 copies/mL (<b>CI</b>)</li> </ul> <p><b>PI-Based Regimens:</b></p> <ul style="list-style-type: none"> <li>• (ATV/c or ATV/r) plus ABC/3TC<sup>a</sup>—<b>only</b> for patients who are HLA-B*5701 negative and with pre-treatment HIV RNA &lt;100,000 copies/mL (<b>CIII</b> for ATV/c and <b>CI</b> for ATV/r)</li> <li>• LPV/r (once<sup>b</sup> or twice daily) plus ABC/3TC<sup>a</sup>—<b>only</b> for patients who are HLA-B*5701 negative (<b>CI</b>)</li> <li>• LPV/r (once<sup>b</sup> or twice daily) plus TDF/FTC<sup>a</sup> (<b>CI</b>)</li> </ul> <p><b>Other Regimens When TDF or ABC Cannot be Used:</b></p> <ul style="list-style-type: none"> <li>• DRV/r plus RAL—<b>only</b> for patients with pre-treatment HIV RNA &lt;100,000 copies/mL and CD4 cell count &gt;200 cells/mm<sup>3</sup> (<b>CI</b>)</li> <li>• LPV/r (twice daily) plus 3TC (twice daily) (<b>CI</b>)</li> </ul>
<p><b>Rating of Recommendations:</b> A = Strong; B = Moderate; C = Optional</p> <p><b>Rating of Evidence:</b> I = Data from randomized controlled trials; II = Data from well-designed nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion</p>

<sup>a</sup> 3TC may be substituted for FTC or vice versa.

<sup>b</sup> Once daily LPV/r is not recommended for pregnant patients.

**Note:** The following are available as co-formulated fixed-dose combination products: ABC/3TC, ATV/c, DRV/c, DTG/ABC/3TC, EFV/TDF/FTC, EVG/c/TDF/FTC, LPV/r, RPV/TDF/FTC, and TDF/FTC.

**Key to Acronyms:** 3TC = lamivudine; ABC = abacavir; ARV = antiretroviral; ATV/c = cobicistat-boosted atazanavir; ATV/r = ritonavir-boosted atazanavir; CrCl = creatinine clearance; DRV/c = cobicistat-boosted darunavir; DRV/r = ritonavir-boosted darunavir; DTG = dolutegravir; EFV = efavirenz; EVG/c/TAF/FTC = elvitegravir/cobicistat/tenofovir alafenamide/emtricitabine; EVG/c/TDF/FTC = elvitegravir/cobicistat/tenofovir DF/emtricitabine; FTC = emtricitabine; INSTI = integrase strand transfer inhibitor; LPV/r = ritonavir-boosted lopinavir; NNRTI = non-nucleoside reverse transcriptase inhibitor; NRTI = nucleoside reverse transcriptase inhibitor; PI = protease inhibitor; RAL = raltegravir; RPV = rilpivirine; RTV = ritonavir; TAF = tenofovir alafenamide; TDF = tenofovir disoproxil fumarate

## Considerations When Selecting a Regimen for Antiretroviral Therapy-Naive Patients

As noted in Table 6, the Recommended Regimens include four INSTI-based regimens and one DRV/r-based regimen for initial therapy. The INSTI-based regimens were selected because of their high virologic efficacy, excellent safety and tolerability profiles, and (with RAL and dolutegravir [DTG]) low number of drug-drug interactions (see the INSTI section for discussion regarding the special characteristics and clinical trial results for each of the 3 Recommended INSTIs). For patients who are at high risk for intermittent therapy because of poor adherence or have transmitted NRTI drug resistance, a PI/r-based treatment is preferred given the PIs high genetic barrier to resistance (see PI section for discussion of the different PK-boosted PIs recommended by the Panel). In some situations, an NNRTI-based regimen may be a better choice for a particular patient. [Table 7](#) provides guidance on regimen selection based on various patient- and regimen-specific characteristics.

## ***Factors to Consider When Selecting an Initial Regimen***

When selecting a regimen for an individual patient, a number of patient and regimen specific characteristics should be considered, with the goal of providing a potent, safe, tolerable, and easy to adhere to regimen for the patient in order to achieve sustained virologic control. Some of the factors can be grouped into the following categories:

### Initial Characteristics of the Patient:

- Pre-treatment HIV RNA level (viral load)
- Pre-treatment CD4 cell count
- HIV genotypic drug resistance testing results
- HLA-B\*5701 status
- Patient preferences
- Patient's anticipated adherence

### Specific Comorbidities or Other Conditions:

- Cardiovascular disease, hyperlipidemia, renal disease, osteoporosis, psychiatric illness, neurologic disease, drug abuse or dependency requiring narcotic replacement therapy
- Pregnancy or pregnancy potential. Clinicians should refer to the latest [Perinatal Guidelines](#) for more detailed recommendations on the safety and effectiveness of ARV drugs during pregnancy.
- Coinfections: hepatitis C (HCV), hepatitis B (HBV), tuberculosis (TB)

### Regimen-Specific Considerations:

- Regimen's genetic barrier to resistance
- Potential adverse drug effects
- Known or potential drug interactions with other medications
- Convenience (e.g., pill burden, dosing frequency, availability of fixed-dose combination products, food requirements)
- Cost (see [Cost Consideration and Antiretroviral Therapy](#) section)

**Table 7. Antiretroviral Regimen Considerations as Initial Therapy based on Specific Clinical Scenarios (page 1 of 3)**

This table is designed to guide clinicians in choosing an initial ARV regimen according to various patient and regimen characteristics and specific clinical scenarios. When more than one scenario applies to a patient, clinicians should review considerations for each relevant scenario and use their clinical judgment to select the most appropriate regimen. This table is intended to guide the initial choice of regimen. However, if a patient is doing well on a particular regimen, it is not necessary to switch to another regimen based on the scenarios outlined in this table.

Please see [Table 8](#) for additional information regarding the advantages and disadvantages of particular ARV medications.

Patient or Regimen Characteristics	Clinical Scenario	Consideration(s)	Rationale/Comments
<b>Pre-ART Characteristics</b>	CD4 count <200 cells/mm <sup>3</sup>	<b>Do Not Use the Following Regimens:</b> <ul style="list-style-type: none"> <li>• RPV-based regimens</li> <li>• DRV/r plus RAL</li> </ul>	Higher rate of virologic failure observed in those with low pre-treatment CD4 cell count
	HIV RNA >100,000 copies/mL	<b>Do Not Use the Following Regimens:</b> <ul style="list-style-type: none"> <li>• RPV-based regimens</li> <li>• ABC/3TC with EFV or ATV/r</li> <li>• DRV/r plus RAL</li> </ul>	Higher rates of virologic failure observed in those with high pre-treatment HIV RNA
	HLA-B*5701 positive	<b>Do not use ABC-containing regimen.</b>	Abacavir hypersensitivity, a potentially fatal reaction, is highly associated with positivity for the HLA-B*5701 allele.
	Must treat before HIV drug resistance results available	<b>Avoid NNRTI-based regimen.</b>	Transmitted mutations conferring NNRTI resistance are more likely than mutations associated with PI or INSTI resistance.  Some experts avoid using INSTI-containing regimens in this setting because of concern regarding their ability to fully suppress viral replication if transmitted NRTI mutations are present.
<b>ART Specific Characteristics</b>	One pill once daily regimen desired	<u>ART Options Include:</u> <ul style="list-style-type: none"> <li>• DTG/ABC/3TC</li> <li>• EFV/TDF/FTC</li> <li>• EVG/c/TDF/FTC</li> <li>• RPV/TDF/FTC (if HIV RNA &lt;100,000 copies/mL and CD4 count &gt;200/mm<sup>3</sup>)</li> </ul>	Available as fixed-dose combination tablets
	Food effects	<u>Regimens that Should be Taken with Food:</u> <ul style="list-style-type: none"> <li>• ATV/r or ATV/c-based regimens</li> <li>• DRV/r or DRV/c-based regimens</li> <li>• EVG/c/TDF/FTC</li> <li>• RPV/TDF/FTC</li> </ul> <u>Regimens that Should be Taken on an Empty Stomach:</u> <ul style="list-style-type: none"> <li>• EFV-based regimens</li> </ul>	Food improves absorption of the listed regimens.  Taking EFV-based regimens with food increases EFV absorption and may increase CNS side effects.



**Table 7. Antiretroviral Regimen Considerations as Initial Therapy based on Specific Clinical Scenarios (page 2 of 3)**

Patient or Regimen Characteristics	Clinical Scenario	Consideration(s)	Rationale/Comments
Presence of Other Conditions	Chronic kidney disease (defined as eGFR <60 mL/min)	<p><b>Consider avoiding TDF.</b></p> <p><u>If eGFR is &lt;70 mL/min, Do Not Use:</u></p> <ul style="list-style-type: none"> <li>• EVG/c/TDF/FTC, or</li> <li>• ATV/c with TDF, or</li> <li>• DRV/c with TDF</li> </ul> <p><u>Options for CKD Patients</u></p> <p><i>Use ABC/3TC if HLA-B*5701 Negative:</i></p> <ul style="list-style-type: none"> <li>• If HIV RNA &gt;100,000 copies/mL, do not use ABC/3TC with EFV or ATV/r.</li> <li>• If CrCl &lt;50 mL/min, do not use coformulated ABC/3TC because 3TC requires dose adjustment.</li> </ul> <p><i>Other Options (See Text for Discussion):</i></p> <ul style="list-style-type: none"> <li>• DRV/r plus RAL (if HIV &lt;100,000/mL and CD4 count &gt;200/mm<sup>3</sup>), or</li> <li>• LPV/r plus 3TC, or</li> <li>• Modify TDF dose</li> </ul>	<p>TDF has been associated with renal tubulopathy.</p> <p><a href="#">See Appendix B, Table 7</a> for recommendations on ARV dose modification.</p>
	Osteoporosis	<p><b>Consider avoiding TDF.</b></p> <p>Use ABC/3TC if HLA-B*5701 negative</p> <p>If HIV RNA &gt;100,000 copies/mL, do not use ABC/3TC plus (EFV or ATV/r)</p>	TDF is associated with greater decrease in bone mineral density along with renal tubulopathy, urine phosphate wasting, and osteomalacia.
	Psychiatric illnesses	<b>Consider avoiding EFV-based regimens.</b>	EFV can exacerbate psychiatric symptoms and may be associated with suicidality.
	HIV-associated dementia (HAD)	<p><b>Avoid EFV-based regimens if possible.</b></p> <p>Favor DRV-based or DTG-based regimen.</p>	<p>EFV neuropsychiatric effects may confound assessment of the effect of ART on improvement of symptoms associated with HAD.</p> <p>Theoretical CNS penetration advantage</p>
	Narcotic replacement therapy required	<p><b>If patient receiving methadone, consider avoiding EFV-based regimen.</b></p> <p>If EFV is used, an increase in methadone dose may be necessary.</p>	EFV reduces methadone concentrations and may lead to withdrawal symptoms.
	High cardiac risk	<b>Consider avoiding ABC- and LPV/r - based regimens.</b>	Increased cardiovascular risk in some studies (see ABC discussion in this section)
	Hyperlipidemia	<p><u>The Following ARV Drug Classes or Drugs have been Associated with Deleterious Effects on Lipids:</u></p> <ul style="list-style-type: none"> <li>• PI/r</li> <li>• ABC</li> <li>• EFV</li> <li>• EVG/c</li> </ul>	TDF has been associated with beneficial lipid effects, thus it may be preferable to ABC.
	Pregnancy	Refer to the <a href="#">Perinatal Antiretroviral Treatment Guidelines</a> .	

**Table 7. Antiretroviral Regimen Considerations as Initial Therapy based on Specific Clinical Scenarios (page 3 of 3)**

Patient or Regimen Characteristics	Clinical Scenario	Consideration(s)	Rationale/Comments
<b>Presence of Co-Infections</b>	HBV infection	Use TDF/FTC (or TDF plus 3TC) whenever possible.  <u>If TDF is Contraindicated:</u> • For treatment of HBV, use FTC or 3TC with entecavir or another drug active against HBV.	TDF, FTC, and 3TC are active against both HIV and HBV. 3TC- or FTC-associated HBV mutations can emerge rapidly when these drugs are used without another HBV-active agent.
	HCV treatment required	Refer to recommendations in the HIV/HCV co-infection section.	
	TB infection	<u>If Rifampin is Used:</u> • EFV-based regimens have the least drug-drug interactions. • If RAL is used, increase RAL dose to 800mg BID. • Use DTG at 50mg BID dose only in patients without selected INSTI mutations (refer to product label).  If using a PI-based regimen, rifabutin should be used in place of rifampin in the TB regimen.	• Rifampin is a strong inducer of CYP3A4 and UGT1A1 enzymes, causing significant decrease in concentrations of PI, INSTI, and RPV. • Rifampin has a less significant effect on EFV concentration than on other NNRTIs, PIs, and INSTIs • Rifabutin is a less potent inducer and is a good option for patients receiving non-EFV-based regimens  Refer to <a href="#">Tables 19a, b, d and e</a> for dosing recommendations for rifamycins used with different ARV agents.

**Key to Acronyms:** 3TC = lamivudine; ABC = abacavir; ATV/r = ritonavir-boosted atazanavir; ARV = antiretroviral; c = cobicistat; CKD = chronic kidney disease; CrCl = creatinine clearance; DRV/r = ritonavir-boosted darunavir; DTG = dolutegravir; eGFR = estimated glomerular filtration rate; EFV = efavirenz; EVG/c/TDF/FTC = elvitegravir/cobicistat/tenofovir/emtricitabine; FDA = Food and Drug Administration; FTC = emtricitabine; HBV = hepatitis B virus; HCV = hepatitis C virus; INSTI = integrase strand transfer inhibitor; LPV/r = ritonavir-boosted lopinavir; NNRTI = non-nucleoside reverse transcriptase inhibitor; NRTI = nucleoside reverse transcriptase inhibitor; PI = protease inhibitor; PI/r = ritonavir-boosted protease inhibitor; RAL = raltegravir; RPV = rilpivirine; RTV = ritonavir; TDF = tenofovir disoproxil fumarate

## Selecting an Initial Antiretroviral Regimen

Initial therapy generally consists of two NRTIs combined with an INSTI, an NNRTI, or a pharmacologically boosted PI. All Recommended and Alternative regimens include the NRTI combination of TDF/FTC or ABC/3TC. Both TDF/FTC and ABC/3TC are available as fixed-dose combination tablets. The choice of NRTI combination is usually guided by differences between TDF and ABC given that FTC and 3TC have comparable efficacy and limited potential for adverse events. Considerations when deciding between TDF and ABC are summarized in [Table 8](#) and in the section on Dual NRTI options (below).

### *Choosing Between an Integrase Strand Transfer Inhibitor-, a Non-Nucleoside Reverse Transcriptase Inhibitor-, or a Protease Inhibitor-Based Regimen*

The choice between an INSTI, NNRTI, or PI as the third drug in an initial ARV regimen should be guided by the regimen's efficacy, genetic barrier to resistance, adverse effects profile, and convenience; the patient's comorbidities; and concomitant medications and the potential for drug-drug interactions (See [Tables 7](#) and [8](#) for guidance). The Panel's Recommended regimens as listed in [Table 6](#) include an INSTI or DRV/r in combination with 2 NRTIs. For most patients, an INSTI-containing regimen will be highly effective, have few adverse

effects, and (with RAL and DTG) have no significant CYP 3A4-associated drug interactions. In addition, in the two head-to-head comparisons between DRV/r- and INSTI-containing regimens, the INSTI was better tolerated, with fewer treatment discontinuations.<sup>4,6</sup> For these reasons, all three currently available INSTIs are included among the Recommended regimens and, in general, should be selected for most patients. An exception is in those individuals with uncertain adherence or in whom treatment needs to begin before resistance testing results are available. In this context, DRV/r may have an important role given its high genetic barrier to resistance and low rate of treatment-emergent resistance during many years of clinical experience.

Alternative Regimens include either an NNRTI-based (EFV or rilpivirine [RPV]) or a PK-enhanced, PI-based (ATV/r, atazanavir/cobicistat [ATV/c], or darunavir/cobicistat [DRV/c]) regimen. Although the NNRTIs EFV or RPV are optimal choices for some patients, these drugs have low genetic barriers to resistance, especially in patients with suboptimal adherence. EFV has a long track record of widespread use in the United States and globally. Most EFV-based regimens have strong virologic efficacy, including in patients with high HIV RNA (except when EFV is used with ABC/3TC). However, the relatively high rate of CNS-related side effects associated with the EFV-based regimens makes them less tolerable than other regimens. RPV has fewer adverse effects than EFV, is available as the smallest coformulated single tablet, and has a favorable lipid profile. However, RPV has lower virologic efficacy in patients with high baseline HIV RNA (>100,000 copies/mL) and low CD4 count (<200 cells/mm<sup>3</sup>). ATV/r has demonstrated excellent virologic efficacy in clinical trials, and has fewer metabolic adverse effects than other boosted PI regimens; however, recent clinical trial data showed that ATV/r had a higher rate of adverse effect-associated drug discontinuation than the comparators (DRV/r and RAL). Thus, despite these favorable attributes, based on the above considerations, EFV-, RPV-, and ATV/r- containing regimens are no longer Recommended Regimens as initial therapy in all patients, and are listed as Alternatives. However, based on individual patient characteristics, some Alternative regimens may actually be the optimal regimen for some patients. Furthermore, patients who are doing well on EFV-, RPV-, and ATV/r- containing regimens should not necessarily be switched to other agents.

### ***Choosing Among Different Drugs from an Antiretroviral Drug Class***

The sections below provide clinicians with comparisons of different currently recommended ARV drugs within a drug class, including information related to the safety and virologic efficacy of different drugs based on clinical trial results and/or post-marketing data, special considerations to take into account, and the rationales for the Panel's recommendations.

### ***Dual-Nucleoside Reverse Transcriptase Inhibitor Options as Part of Initial Combination Therapy***

#### **Summary**

TDF/FTC and ABC/3TC are NRTI combinations commonly used for initial therapy. [Table 6](#) provides recommendations and ratings for the individual regimens. These recommendations are based on the virologic potency and durability, short- and long-term toxicity, and dosing convenience of these drugs.

#### **Clinical Trials Comparing Abacavir/Lamivudine to Tenofovir/Emtricitabine**

Several randomized controlled trials in ART-naïve participants compared ABC/3TC to TDF/FTC, each with the same<sup>7-9</sup> or a different third ARV drug (also see discussion in the DTG section).<sup>10</sup>

- The ACTG 5202 study, a randomized controlled trial in more than 1,800 participants, evaluated the efficacy and safety of ABC/3TC and TDF/FTC when each was used in combination with either EFV or ATV/r.
  - Treatment randomization was stratified on the basis of a screening HIV RNA level <100,000 copies/mL or ≥100,000 copies/mL. HLA B\*5701 testing was not required before study entry.
  - A Data Safety Monitoring Board recommended early termination of the ≥100,000 copies/mL stratification group because of a significantly shorter time to study-defined virologic failure in the

ABC/3TC arm than in the TDF/FTC arm.<sup>7</sup> This difference in time to virologic failure between the arms was observed regardless of whether the third active drug was EFV or ATV/r.

- There was no difference between ABC/3TC and TDF/FTC in time to virologic failure for participants who had plasma HIV RNA <100,000 copies/mL at screening.<sup>11</sup>
- The ASSERT study compared open label ABC/3TC with TDF/FTC in 385 HLA B\*5701-negative, ART-naive patients; all participants also received EFV. The primary study endpoint was renal safety of the regimens. At week 48, the proportion of participants with HIV RNA <50 copies/mL was lower among ABC/3TC-treated participants than among TDF/FTC-treated participants.<sup>8</sup>
- In the HEAT study, 688 participants received ABC/3TC or TDF/FTC in combination with once-daily LPV/r. Virologic efficacy was similar in the two study arms. In a subgroup analysis of patients with baseline HIV RNA ≥100,000 copies/mL, the proportion of participants who achieved HIV RNA <50 copies/mL at 96 weeks did not differ between the two regimens.<sup>9</sup>

## ***Dual-Nucleoside Reverse Transcriptase Inhibitor Choices***

**Note:** In alphabetical order.

### **Abacavir/Lamivudine**

ABC plus 3TC has been studied in combination with EFV, several PIs, and DTG in ART-naive patients.<sup>10,12-14</sup>

#### Adverse Effects:

##### *Hypersensitivity Reactions:*

- Clinically suspected hypersensitivity reactions (HSRs) were observed in 5% to 8% of individuals who started ABC in clinical trials conducted before the use of HLA-B\*5701 testing. The risk of HSRs is highly associated with the presence of the HLA-B\*5701 allele.<sup>15,16</sup> HLA-B\*5701 testing should precede use of ABC. ABC should not be given to patients who test positive for HLA-B\*5701 and based on a positive test result, ABC hypersensitivity should be noted on a patient's allergy list. Patients who are HLA-B\*5701 negative are far less likely to experience an HSR, but they should be counseled about the symptoms of the reaction. Patients who discontinue ABC because of a suspected HSR should never be re-challenged, regardless of their HLA-B\*5701 status.

##### *Cardiovascular Risk:*

- An association between ABC use and myocardial infarction (MI) was first reported in the D:A:D study. This large, multinational observational study group found that recent (within 6 months) or current use of ABC was associated with an increased risk of MI, particularly in participants with pre-existing cardiac risk factors.<sup>17,18</sup>
- Since the D:A:D report, several studies have evaluated the relationship between ABC therapy and cardiovascular events. Some studies have found an association;<sup>19-22</sup> others, including an FDA meta-analysis of 26 randomized clinical trials that evaluated ABC, have not.<sup>23-27</sup>
- No consensus has been reached on the association between ABC use and MI risk or the mechanism for such an association.

#### Other Factors and Considerations:

- ABC/3TC is available as a co-formulated tablet and as a coformulated single-tablet regimen with DTG.
- ABC and 3TC are available separately in generic tablet formulations.
- ABC does not cause renal dysfunction and is an alternative to TDF in patients with underlying renal dysfunction or who are at risk for renal effects. No dosage adjustment is required in patients with renal dysfunction.

### Panel's Recommendations:

- ABC should only be prescribed for patients who are HLA B\*5701 negative.
- On the basis of clinical trial safety and efficacy data, experience in clinical practice, and the availability of ABC/3TC as a component of co-formulated products, the Panel classifies ABC/3TC plus DTG as a Recommended regimen (**AI**) (see discussion regarding DTG in this section regarding the clinical efficacy data for ABC/3TC plus DTG) .
- ABC/3TC use with EFV, ATV/r, or ATV/c is only recommended for patients with pre-treatment HIV RNA <100,000 copies/mL.
- ABC/3TC is a part of several Alternative or Other regimens when combined with another ARV drug. See [Table 6](#) for more detailed recommendations on use of ABC/3TC with other drugs.
- ABC should be used with caution or avoided in patients with known high cardiovascular risk.

### **Tenofovir/Emtricitabine**

TDF, with either 3TC or FTC, has been studied in combination with EFV, RPV, several boosted PIs, EVG/c, RAL, and DTG in randomized clinical trials.<sup>28-37</sup>

### Adverse Effects:

- New onset or worsening renal impairment has been associated with TDF use.<sup>38,39</sup> Risk factors may include advanced HIV disease; longer treatment history; low body weight, especially in females;<sup>40</sup> and pre-existing renal impairment.<sup>41</sup>
  - Concomitant use of a PK-enhanced regimen (with a PI or EVG) can increase TDF concentrations; studies have suggested a greater risk of renal dysfunction when TDF is used in these regimens.<sup>39,42-46</sup>
- While initiation of all NRTI-containing regimens has been associated with a decrease in bone mineral density (BMD), the loss of BMD is greater with TDF-containing regimens. For example, in two randomized studies comparing TDF/FTC with ABC/3TC, participants receiving TDF/FTC experienced a significantly greater decline in bone mineral density than ABC/3TC-treated participants.<sup>47,48</sup> Following an early decline after ART initiation, BMD generally stabilizes.
- Cases of osteomalacia associated with proximal renal tubulopathy have been reported with the use of TDF.<sup>49</sup>

### Other Factors and Considerations:

- TDF/FTC is available in fixed-dose drug combinations with EFV, EVG/c, and RPV, allowing the regimens to be administered as a single pill, given once daily.
- Renal function, urine glucose, and urine protein should be assessed before initiating treatment with TDF and periodically during treatment (see [Laboratory Monitoring](#) section). In patients who have pre-existing renal insufficiency (CrCl <60 mL/min),<sup>50</sup> TDF should generally be avoided. If TDF is used, dosage adjustment is required if the patient's CrCl falls below 50 mL/min (see [Appendix B, Table 7](#) for dosage recommendations).
- Both TDF and FTC are active against HBV. In patients with HIV/HBV coinfection, TDF/FTC should be used as the NRTI pair of the ART regimen because the drugs have activity against both viruses (also see [HIV/HBV Coinfection](#) section).

### Panel's Recommendations:

- On the basis of clinical trial safety and efficacy data, long-term experience in clinical practice, and the combination's availability as a component of co-formulated products, the Panel considers TDF/FTC as a



Recommended NRTI combination for initial ART in treatment-naïve patients when combined with DTG, EVG/c, RAL, or DRV/r. See [Table 6](#) for recommendations regarding use of TDF/FTC with other drugs.

- TDF should be used with caution or avoided in patients with renal disease and osteoporosis.

## Integrase Strand Transfer Inhibitor-Based Regimens

### Summary

Three INSTIs—DTG, EVG, and RAL—are currently approved for HIV-infected, ARV-naïve patients. DTG and EVG are currently available as components of one-tablet once daily complete regimens: DTG is coformulated with ABC/3TC; EVG is coformulated with a PK enhancer (COBI) and TDF/FTC. EVG is also available as a single agent designed to be used in combination with PI/r in ART-experienced patients, and is not recommended for use in treatment-naïve patients.

### Recommended Integrase Strand Transfer Inhibitor-Based Regimens

**Note:** In alphabetical order.

#### Dolutegravir

##### Efficacy in Clinical Trials:

The efficacy of DTG in treatment-naïve patients has been evaluated in three fully powered clinical trials, including two randomized double-blinded clinical trials and one randomized open-label clinical trial. In these three trials, DTG-based regimens were non-inferior or superior to a comparator INSTI, NNRTI, or PI-based regimen. The primary efficacy endpoint in these clinical trials was the proportion of participants with plasma HIV RNA <50 copies/mL.

- The SPRING-2 trial compared DTG 50 mg once daily to RAL 400 mg twice daily, each in combination with investigator-selected NRTI ABC/3TC or TDF/FTC, in 822 participants. At week 96, DTG was non-inferior to RAL.<sup>37</sup>
- The SINGLE trial compared DTG 50 mg once daily plus ABC/3TC to EFV/TDF/FTC in 833 participants. At week 48, DTG was superior to EFV, primarily because the study treatment discontinuation rate was higher in the EFV arm than in the DTG arm.<sup>10</sup> At week 144, DTG plus ABC/3TC remained superior to EFV/TDF/FTC.<sup>51</sup>
- The FLAMINGO study, a randomized open-label clinical trial, compared DTG 50 mg once daily to DRV/r 800 mg/100 mg once daily, each in combination with investigator-selected ABC/3TC or TDF/FTC. At week 48, DTG was superior to DRV/r because of the higher rate of discontinuation in the DRV/r arm.<sup>6,52</sup> The difference in response rates favoring DTG was greater in patients with pre-treatment HIV RNA levels >100,000 copies/mL. At week 96, DTG remained superior to DRV/r.<sup>53</sup>

##### Adverse Effects:

- DTG is generally well tolerated. The most common adverse reactions of moderate to severe intensity with an incidence  $\geq 2\%$  in the clinical trials were insomnia and headache. Cases of hypersensitivity reactions were reported in <1% of trial participants.

##### Other Factors and Considerations:

- In treatment-naïve patients, DTG is given once daily, with or without food.
- DTG decreases tubular secretion of creatinine without affecting glomerular function, with increases in serum creatinine observed within the first 4 weeks of treatment (mean increase in serum creatinine was 0.11 mg/dL after 48 weeks).



- DTG has few drug interactions. DTG increases metformin levels approximately two-fold; close monitoring for metformin adverse effects is advisable. Rifampin decreases DTG levels; therefore, an increase in dosing of DTG to 50 mg twice daily is required.
- DTG absorption may be reduced when the ARV is coadministered with polyvalent cations (see [Drug Interaction](#) section). DTG should be taken at least 2 hours before or 6 hours after cation-containing antacids or laxatives. Alternatively, DTG and supplements containing calcium or iron can be taken simultaneously with food.
- Treatment-emergent mutations that confer DTG resistance have not been reported in patients receiving DTG for initial therapy, which suggests that DTG has a higher genetic barrier to resistance than other INSTIs.

#### Panel's Recommendation:

- On the basis of clinical trial data, the Panel categorizes DTG in combination with either ABC/3TC or TDF/FTC as a Recommended regimen in ART-naïve patients (**AI**).

#### **Elvitegravir**

EVG is available as a component of a four-drug, fixed-dose combination product containing EVG, COBI, TDF, and FTC (EVG/c/TDF/FTC). COBI is a specific, potent CYP3A inhibitor that has no activity against HIV. It acts as a PK enhancer of EVG, which allows for once daily dosing of the combination.

#### Efficacy in Clinical Trials:

The efficacy of EVG/c/TDF/FTC in ARV-naïve participants has been evaluated in two randomized, double-blind active-controlled trials.

- At 144 weeks, EVG/c/TDF/FTC was non-inferior to fixed-dose EFV/TDF/FTC.<sup>54</sup>
- EVG/c/TDF/FTC was also found to be non-inferior to a combination containing ATV/r plus TDF/FTC.<sup>55</sup>

#### Adverse Effects:

- The most common adverse events reported with EVG/c/TDF/FTC were diarrhea, nausea, upper respiratory infection, and headache.<sup>54,55</sup>

#### Other Factors and Considerations:

- EVG is metabolized primarily by CYP3A enzymes; as a result, CYP3A inducers or inhibitors may alter EVG concentrations.
- Because COBI inhibits CYP3A, it interacts with a number of medications that are metabolized by this enzyme (see [Drug-Drug Interactions](#) section).<sup>56</sup>
- EVG plasma concentrations are lower when the ARV is administered simultaneously with polyvalent cation-containing antacids or supplements (see [Drug Interaction](#) section). Separate EVG/c/TDF/FTC and polyvalent antacid administration by at least 2 hours; administer polyvalent cation-containing supplements at least 2 hours before or 6 hours after EVG dosing.
- COBI inhibits active tubular secretion of creatinine, resulting in increases in serum creatinine and a reduction in estimated CrCl without reducing glomerular function.<sup>57</sup> Patients with a confirmed increase in serum creatinine greater than 0.4 mg/dL from baseline while taking EVG/c/TDF/FTC should be closely monitored and evaluated for evidence of TDF-related proximal renal tubulopathy.<sup>46</sup>
- EVG/c/TDF/FTC is **not recommended** for patients with pre-treatment estimated CrCl <70 mL/min.<sup>46</sup>
- At the time of virologic failure, INSTI-associated mutations were detected in some EVG/c/TDF/FTC-treated patients whose therapy failed.<sup>54,55</sup> These mutations conferred cross-resistance to RAL, with most retaining susceptibility to DTG.

### Panel's Recommendation:

- On the basis of the above factors, the Panel classifies EVG/c/TDF/FTC as a Recommended regimen in ART-naïve patients **(AI)**.

### **Raltegravir**

RAL was the first INSTI approved for use in both ARV-naïve and ARV-experienced patients.

### Efficacy in Clinical Trials:

The efficacy of RAL (with either TDF/FTC or ABC/3TC) as initial therapy has been evaluated in two randomized, double-blinded, controlled clinical trials, and a third open-label randomized trial.

- STARTMRK compared RAL 400 mg twice daily to EFV 600 mg once daily, each in combination with TDF/FTC. RAL was non-inferior to EFV at 48 weeks.<sup>33</sup> RAL was superior to EFV at 4 and 5 years,<sup>36,58</sup> in part because of more frequent discontinuations due to adverse events in the EFV group than in the RAL group.
- The SPRING-2 trial compared DTG 50 mg once daily to RAL 400 mg twice daily, each in combination with investigator-selected ABC/3TC or TDF/FTC. At week 96, DTG was non-inferior to RAL.
- The SPRING-2 trial also provided non-randomized data on the efficacy of RAL plus ABC/3TC. In this trial, 164 participants (39 and 125 with baseline viral loads  $\geq 100,000$  copies/mL and  $< 100,000$  copies/mL, respectively) received RAL in combination with ABC/3TC. After 96 weeks, there was no difference in virologic response between the ABC/3TC and TDF/FTC groups when RAL was given as the third drug.<sup>37</sup>
- ACTG A5257, a large randomized open-label trial, compared 3 NNRTI-sparing regimens containing RAL, ATV/r, or DRV/r, each given with TDF/FTC. At week 96, all 3 regimens had similar virologic efficacy, but RAL was superior to both ATV/r and DRV/r for the combined endpoints of virologic efficacy and tolerability. Lipids increased more in participants in the PI/r arms than in the RAL arm, and bone mineral density decreased to a greater extent in participants in the PI/r arms than in participants in the RAL arm.<sup>4</sup>

### Adverse Effects:

- RAL use has been associated with creatine kinase elevations. Myositis and rhabdomyolysis have been reported.
- Rare cases of severe skin reactions and systemic hypersensitivity reactions in patients who received RAL have been reported during post-marketing surveillance.<sup>59</sup>

### Other Factors and Considerations:

- RAL must be administered twice daily—a potential disadvantage when comparing RAL-based treatment with other Recommended regimens.
- Coadministration of RAL with aluminum and/or magnesium-containing antacids can reduce absorption of RAL and is not recommended. Raltegravir may be coadministered with calcium carbonate-containing antacids. Polyvalent cation-containing supplements may also reduce absorption of RAL; thus, RAL should be given at least 2 hours before or 6 hours after cation-containing supplements.
- RAL has a lower genetic barrier to resistance than RTV-boosted PIs and DTG.

### Panel's Recommendations:

- On the basis of these data and long-term clinical experience with RAL, the Panel considers RAL plus TDF/FTC as a Recommended regimen in ARV-naïve patients **(AI)**.

- Because few patients have received RAL plus ABC/3TC in clinical trials or practice and there has not been a randomized trial comparing ABC/3TC plus RAL to TDF/FTC plus RAL, the Panel categorizes RAL plus ABC/3TC as an Other therapy (**BII**).

## Non-Nucleoside Reverse Transcriptase Inhibitor-Based Regimens

### Summary

Five NNRTIs (delavirdine [DLV], EFV, etravirine [ETR], nevirapine [NVP], and RPV) are currently FDA approved.

NNRTI-based regimens have demonstrated virologic potency and durability. The major disadvantages of currently available NNRTIs are the prevalence of NNRTI-resistant viral strains in ART-naïve patients<sup>60</sup> and the drugs' low genetic barrier for the development of resistance. Resistance testing should be performed to guide therapy selection for ART-naïve patients (see [Drug-Resistance Testing](#)). High-level resistance to all NNRTIs (except ETR) may occur with a single mutation; within-class cross-resistance is common. In RPV-treated patients, the presence of RPV resistance mutations at virologic failure may confer cross resistance to other NNRTIs, including ETR.<sup>61,62</sup>

### Efavirenz

EFV is an NNRTI approved for use in combination with 2-NRTIs for ART-naïve patients.

#### Efficacy in Clinical Trials:

Large randomized, controlled trials and cohort studies in ART-naïve patients have demonstrated potent and durable viral suppression in patients treated with EFV plus two NRTIs. In clinical trials, EFV-based regimens in ART-naïve patients have demonstrated superiority or non-inferiority to several comparator regimens.

- In ACTG 5142, EFV was superior to LPV/r, although drug resistance was more common after EFV failure than after LPV/r failure.<sup>63</sup>
- In the 2NN study, compared to EFV, NVP did not meet non-inferiority criteria.<sup>64</sup>
- In ACTG 5202, EFV was comparable to ATV/r when each was given with either TDF/FTC or ABC/3TC.<sup>65</sup>
- In the ECHO and THRIVE studies, EFV was non-inferior to RPV, with less virologic failure but more discontinuations due to adverse events. The virologic advantage of EFV was most notable in participants with pre-ART viral loads >100,000 copies/mL, and NRTI and NNRTI resistance was more frequent with RPV failure.<sup>66</sup>
- In the GS 102 study, EFV/TDF/FTC was non-inferior to EVG/c/TDF/FTC.<sup>54</sup>

More recently, some regimens have demonstrated superiority to EFV, based primarily on fewer discontinuations because of adverse events.

- In the SINGLE trial, a DTG-based regimen was superior to EFV at the primary endpoint of viral suppression at Week 48.<sup>10</sup>
- In the STARTMRK trial, RAL was non-inferior to EFV at 48 weeks.<sup>33</sup> RAL was superior to EFV at 4 and 5 years,<sup>36,58</sup> in part because of more frequent discontinuations due to adverse events in the EFV group than in the RAL group.
- In the open-label STaR trial, participants with baseline viral loads ≤100,000 copies/mL had higher rates of treatment success on RPV than on EFV.<sup>67</sup>

A recent multinational randomized placebo-controlled trial compared two once daily doses of EFV (combined with TDF/FTC): EFV 600 mg (standard dose) versus EFV 400 mg (reduced dose). At 48 weeks,

EFV 400 mg was non-inferior to EFV 600 mg for rate of viral suppression.<sup>68</sup> Study drug-related adverse events were less frequent in the EFV 400 mg group than in the 600 mg group. Although there were fewer self-reported CNS events in the 400 mg group, the two groups had similar rates of psychiatric events. Unlike the 600 mg dose of EFV, the 400 mg dose is not approved for initial treatment and is not co-formulated as a component of a single pill regimen.

#### Adverse Effects:

- EFV can cause CNS side effects, such as abnormal dreams, dizziness, headache, and depression, which resolve over a period of days to weeks in most patients. However, more subtle, long-term neuropsychiatric effects can occur. A recent analysis of 4 AIDS Clinical Trial Group (ACTG) comparative trials showed a higher rate of suicidality (i.e., reported suicidal ideation or attempted or completed suicide) among EFV-treated patients than among patients taking comparator regimens.<sup>5</sup> This association, however, was not found in analyses of two large observational cohorts.<sup>69,70</sup>
- EFV may cause elevation in LDL cholesterol and triglycerides.

#### Other Factors and Considerations:

- EFV is formulated both as a single-drug tablet and in a fixed-dose combination tablet of EFV/TDF/FTC that allows for once daily dosing.
- EFV is a substrate of CYP3A4 and an inducer of CYP3A4 and 2D6 and therefore may potentially interact with other drugs using the same pathways.
- EFV has been associated with CNS birth defects in non-human primates, and cases of neural tube defects have been reported after first trimester exposure in humans.<sup>71</sup> Alternative regimens should be considered in women who are planning to become pregnant or who are sexually active and not using effective contraception. Because the risk of neural tube defects is restricted to the first 5 to 6 weeks of pregnancy, before pregnancy is usually recognized, a suppressive EFV-based regimen can be continued in pregnant women who present for antenatal care in the first trimester, or may be initiated after the first trimester (see [Perinatal Guidelines](#)).

#### Panel's Recommendations:

- Given the availability of regimens with fewer treatment-limiting adverse events with non-inferior or superior efficacy, the Panel classifies EFV/TDF/FTC as an Alternative regimen for ART-naïve patients (**BI**).
- Given virologic and pharmacogenetic parameters that limit its use in some patients, the Panel recommends EFV with ABC/3TC as an Other regimen, and **only** for patients with a pre-ART viral load <100,000 copies/mL and negative HLA B\*5701 status (see discussion in ABC/3TC section) (**CI**).
- EFV at a reduced dose has not been studied in the U.S. population. The Panel cannot recommend use of reduced dose EFV until further data to support its use in the U.S. population are available.

#### **Rilpivirine**

RPV is an NNRTI approved for use in combination with NRTIs for ART-naïve patients with pre-treatment viral loads <100,000 copies/mL.

#### Efficacy in Clinical Trials:

Two Phase 3 randomized, double-blinded clinical trials, ECHO and THRIVE, compared RPV and EFV, each combined with 2 NRTIs.<sup>66</sup> At 96 weeks, the following findings were reported:

- RPV was non-inferior to EFV overall.
- Among participants with a pre-ART viral load >100,000 copies/mL, more RPV-treated than EFV-treated participants experienced virologic failure. Moreover, in this subgroup of participants with virologic

failure, NNRTI and NRTI resistance was more frequently identified in those treated with RPV.

- Among the RPV-treated participants, the rate of virologic failure was greater in those with pre-treatment CD4 counts  $<200$  cells/mm<sup>3</sup> than in those with CD4 counts  $\geq 200$  cells/mm<sup>3</sup>.

STaR, a Phase 3b, open-label study, compared the fixed-dose combinations of RPV/TDF/FTC and EFV/TDF/FTC in 786 treatment-naïve patients. At 96 weeks, the following key findings were reported:<sup>67</sup>

- RPV was non-inferior to EFV overall.
- RPV was superior to EFV in patients with pre-ART viral loads  $\leq 100,000$  copies/mL and non-inferior in those with pre-ART viral loads  $>100,000$  copies/mL. In patients with pre-ART viral loads  $>500,000$  copies/mL, virologic failure was more common in RPV-treated patients than in EFV-treated patients.
- At 48 weeks, NRTI and NNRTI resistance occurred in 2% and 1% of RPV- and EFV-treated patients, respectively, with viral loads  $\leq 100,000$ ; in 5% and 0% of RPV- and EFV-treated patients, respectively, with viral loads 100,000 to 500,000; and in 19% and 4% of RPV- and EFV-treated patients, respectively, with viral loads  $>500,000$  copies/mL.

#### Adverse Effects:

- RPV is generally well tolerated. In the ECHO, THRIVE, and STaR trials, fewer CNS adverse events (e.g., abnormal dreams, dizziness, psychiatric side effects), skin rash, and dyslipidemia were reported in the RPV arms than the EFV arms, and fewer patients in the RPV arms discontinued therapy due to adverse events.

#### Other Factors and Considerations:

- RPV is formulated both as a single-drug tablet and in a fixed-dose combination tablet with TDF/FTC. Among available single pill regimens, it is the smallest tablet.
- RPV/TDF/FTC is given as a once daily regimen, and must be administered with a meal (at least 400 kcal).
- The oral drug absorption of RPV can be significantly reduced in the presence of acid-lowering agents. RPV is contraindicated in patients who are receiving proton pump inhibitors, and should be used with caution in those receiving H<sub>2</sub> antagonists or antacids (see [Drug Interaction](#) section for dosing recommendations).
- RPV is primarily metabolized in the liver by CYP3A enzyme; its plasma concentration may be affected in the presence of CYP3A inhibitors or inducers (see [Drug Interaction](#) section).
- At higher than the approved dose of 25 mg, RPV may cause QTc interval prolongation. RPV should be used with caution when coadministered with a drug known to increase the risk of Torsades de Pointes.

#### Panel's Recommendations:

- Given the availability of other effective regimens that do not have virologic and immunologic prerequisites to initiate treatment, the Panel recommends RPV/TDF/FTC as an Alternative regimen.
- Use of RPV with TDF/FTC should be limited to ART-naïve patients with pre-treatment viral load  $<100,000$  copies/mL and CD4 count  $>200$  cells/mm<sup>3</sup> (**BI**).
- Data on RPV with ABC/3TC are insufficient to consider recommending this regimen as a Recommended, Alternative, or Other regimen.

## Protease Inhibitor-Based Regimens

### *Summary*

FDA-approved PIs include ATV, ATV/c, DRV, DRV/c, fosamprenavir (FPV), indinavir (IDV), LPV/r, nelfinavir (NFV), ritonavir (RTV), saquinavir (SQV), and tipranavir (TPV). PI-based regimens (particularly



with PK enhancement) have demonstrated virologic potency and (for those with RTV boosting) durability in treatment-naïve patients and a high genetic barrier to resistance. Few or no PI mutations are detected when a patient's first PI-based regimen fails, which is not the case with NNRTI- and some INSTI-based regimens.<sup>72,73</sup> All PIs (PK enhanced by either RTV or COBI) inhibit the cytochrome (CYP) 450 3A isoenzyme, which may lead to significant drug-drug interactions (see [Drug Interactions](#) section). Each PI has specific characteristics related to its virologic potency, adverse effects profile, and PK properties. The characteristics of Recommended and Alternative PIs are listed in [Table 8](#) and [Appendix B, Table 3](#).

A number of metabolic abnormalities, including dyslipidemia and insulin resistance, have been associated with PI use. The currently available PIs differ in their propensity to cause these metabolic complications, which also depends on the dose of RTV used as a pharmacokinetic enhancing agent. Two large observational cohort studies suggest that LPV/r, IDV, FPV, or FPV/r may be associated with increased rates of MI or stroke.<sup>18,24</sup> This association was not seen with ATV.<sup>74</sup> Because of the limited number of patients receiving DRV/r, this boosted-PI was not included in the analysis of the two studies.

Recommended PIs for use in ART-naïve patients should have proven virologic efficacy, once daily dosing, a low pill count, and good tolerability. On the basis of these criteria, the Panel considers once-daily DRV/r plus TDF/FTC as a Recommended PI. In a large, randomized controlled trial comparing DRV/r, ATV/r, and RAL, all in combination with TDF/FTC, all three regimens achieved similar virologic suppression rates; however, the proportion of patients who discontinued their assigned treatment because of adverse effects was greater in the ATV/r arm than in the other two arms.<sup>4</sup> Because of its higher rate of adverse effects, the Panel now classifies ATV/r plus TDF/FTC as an Alternative regimen (**BI**). ATV/c- and DRV/c-based regimens are considered Alternative PI regimens for the reasons detailed below.

LPV/r has twice the daily dose of RTV as other PI/r and is associated with more metabolic complications and gastrointestinal side effects than PK-enhanced ATV or DRV. LPV/r remains as an Other PI/r because it is currently the only PI co-formulated with RTV and it has extended experience in clinical trials and practice. Compared to other PIs, FPV/r, unboosted ATV, and SQV/r have disadvantages such as greater pill burden, lower efficacy, or increased toxicity, and thus are no longer included as an option for initial therapy. Nonetheless, patients who are doing well on regimens containing these PIs should not necessarily be switched to other agents.

## ***Recommended Protease Inhibitor-Based Regimen***

### **Darunavir/Ritonavir**

#### Efficacy in Clinical Trials:

- The ARTEMIS study compared DRV/r (800/100 mg once daily) with LPV/r (800/200 mg once daily or 400/100 mg twice daily), both in combination with TDF/FTC, in a randomized, open-label, non-inferiority trial. DRV/r was non-inferior to LPV/r at week 48,<sup>31</sup> and superior at week 192.<sup>75</sup> Among participants with baseline HIV RNA levels >100,000 copies/mL, virologic response rates were lower in the LPV/r arm than in the DRV/r arm.
- The FLAMINGO study compared DRV/r with DTG, each in combination with two NRTIs, in 488 ART-naïve participants. The rate of virologic suppression at week 48 was significantly greater among those who received DTG than in those who received DRV/r, largely because of more drug discontinuations in the DRV/r group.<sup>6</sup>
- A small retrospective study that followed participants for 48 weeks suggested that DRV/r plus ABC/3TC may be effective in treatment-naïve patients.<sup>76</sup>
- The ACTG A5257 study showed similar virologic efficacy for DRV/r, ATV/r, and RAL, but more participants in the ATV/r group discontinued randomized treatment because of adverse events.<sup>4</sup>



### Adverse Effects:

- In the ARTEMIS Study, grades 2 to 4 adverse events, primarily diarrhea, were seen less frequently in DRV/r recipients than in LPV/r recipients.
- Patients starting DRV/r may develop a skin rash, which is usually mild-to-moderately severe and self-limited. Treatment discontinuation is necessary on rare occasions when severe rash with fever or elevated transaminases occur.

### Other Factors and Considerations:

- DRV/r is administered once daily with food in treatment-naïve patients.
- DRV has a sulfonamide moiety, and should be used with caution in patients with severe sulfonamide allergies. In clinical trials, the incidence and severity of rash were similar in participants who did or did not have a history of sulfonamide allergy. Most patients with sulfonamide allergy are able to tolerate DRV.
- DRV/r is a potent CYP3A4 inhibitor, and may lead to significant interactions with other medications metabolized through this same pathway (see [Drug Interactions](#) section).

### Panel's Recommendation:

- On the basis of efficacy and safety data from clinical trials and clinical experience, the Panel classifies DRV/r with TDF/FTC as a Recommended regimen (**AI**). DRV/r with ABC/3TC is considered an Alternative regimen because there are fewer studies to support its use (**BII**).

## ***Alternative Protease Inhibitor-Based Regimens***

### **Atazanavir/Ritonavir or Atazanavir/Cobicistat**

#### Efficacy in Clinical Trials:

- The CASTLE study compared once-daily ATV/r (300/100 mg) with twice-daily LPV/r (400/100 mg), each in combination with TDF/FTC. In this open-label, non-inferiority study, the 2 regimens showed similar virologic and CD4 responses at 48 weeks<sup>30</sup> and at 96 weeks.<sup>77</sup>
- The ACTG A5202 study compared open-label ATV/r and EFV, each given in combination with placebo-controlled TDF/FTC or ABC/3TC. Efficacy was similar in the ATV/r and EFV groups.<sup>65</sup> In a separate analysis, women assigned to ATV/r were found to have a higher risk of virologic failure than women assigned to EFV or men assigned to ATV/r.<sup>78</sup>
- In a study comparing ATV/r plus TDF/FTC to EVG/c/TDF/FTC, virologic suppression rates through 144 weeks were similar in the two groups.<sup>55</sup>
- ACTG A5257, a large randomized open-label trial, compared ATV/r with DRV/r or RAL, each given with TDF/FTC. At week 96, all 3 regimens had similar virologic efficacy. However, a significantly higher proportion of patients in the ATV/r arm discontinued randomized treatment because of adverse events, mostly for elevated indirect bilirubin/jaundice or gastrointestinal toxicities. Lipid changes in participants in the ATV/r and DRV/r arms were similar. Bone mineral density decreased to a greater extent in participants in the ATV/r and DRV/r arms than in participants in the RAL arm.<sup>4</sup>
- The Gilead Study 114 enrolled 692 treatment-naïve patients. All patients received TDF/FTC and ATV, and were randomized to receive either RTV or COBI as PK enhancers. Both RTV and COBI were given as a separate pill with matching placebos. At 48 weeks, similar percentages of patients achieved virologic suppression, had adverse events, and changes in serum creatinine and indirect bilirubin levels.<sup>79</sup>

### Adverse Effects:

- The main adverse effect associated with ATV/c or ATV/r is reversible indirect hyperbilirubinemia, with or without jaundice or scleral icterus, but without concomitant hepatic transaminase elevations.

- Nephrolithiasis,<sup>80-82</sup> nephrotoxicity,<sup>83</sup> and cholelithiasis<sup>84</sup> have also been reported in patients who received ATV, with or without RTV.
- Both ATV/c and ATV/r can cause gastrointestinal side effects including diarrhea.

#### Other Factors and Considerations:

- ATV/c and ATV/r are dosed once daily and with food.
- ATV requires acidic gastric pH for dissolution. As a result, concomitant use of drugs that raise gastric pH (e.g., antacids, H<sub>2</sub> antagonists, and particularly PPIs) may impair absorption of ATV. [Table 19a](#) provides recommendations for use of ATV/c or ATV/r with these agents.
- ATV/c and ATV/r are potent CYP3A4 inhibitors and may have significant interactions with other medications metabolized through this same pathway (see [Drug Interaction](#) section).
- ATV/c coadministered with TDF/FTC is **not recommended** for patients with CrCl <70 mL/min.

#### Panel's Recommendations:

- On the basis of clinical trial safety and efficacy data, the Panel classifies ATV/r and ATV/c plus TDF/FTC as Alternative regimens for ART-naïve patients regardless of pre-treatment HIV RNA (**BI**).
- Because of an inferior virologic response seen in patients with a high baseline viral load, the Panel recommends ATV/r or ATV/c plus ABC/3TC as Other regimens. Use of the regimens should be limited to patients with pre-ART HIV RNA <100,000 copies/mL (**CI**).
- As noted earlier, ATV/c plus TDF/FTC is not recommended for patients with CrCl <70 mL/min.

#### **Darunavir/Cobicistat**

A combination of (DRV 800 mg with COBI 150 mg) is bioequivalent to (DRV 800 mg with RTV 100 mg) in healthy volunteers.<sup>85</sup>

#### Efficacy in Clinical Trial:

- In a single arm trial of treatment-naïve (94%) and treatment-experienced (6%) patients, the co-formulated DRV/c 800 mg/150 mg tablet was evaluated in combination with investigator-selected NRTI/NtRTI (99% of participants were given TDF/FTC). At week 48, 81% of participants achieved HIV RNA <50 copies/mL; 5% of participants discontinued treatment because of adverse events.<sup>86</sup>

#### Adverse Effects:

- In the single arm trial, the most common treatment emergent adverse events were diarrhea, nausea, and headache.

#### Other Factors:

- (DRV 800 mg and COBI 150 mg) is available as a co-formulated tablet.
- Coadministration with TDF is not recommended in patients with CrCl <70 mL/min.

#### Panel's Recommendation:

- On the basis of the bioequivalence study and the single arm trial, the Panel recommends DRV/c plus TDF/FTC (**BII**) and DRV/c plus ABC/3TC (**BIII**) as Alternative Regimens for ART-naïve patients.
- As noted earlier, DRV/c plus TDF/FTC is **not recommended** for patients with CrCl <70 mL/min.

## ***Other Protease Inhibitor-Based Regimens***

### **Lopinavir/Ritonavir**

#### Efficacy in Clinical Trials:

- A 7-year follow-up study of LPV/r and 2 NRTIs showed sustained virologic suppression in patients who were maintained on the originally assigned regimen.<sup>87</sup>
- Results of clinical trials that compared LPV/r with ATV/r and DRV/r are discussed above, demonstrating more favorable safety and tolerability of ATV/r and DRV/r.
- In the ACTG 5142 study, at 96 weeks, a smaller proportion of patients who received LPV/r plus 2 NRTIs achieved viral suppression (HIV RNA <50 copies/mL) than those who received EFV plus 2 NRTIs. However, the CD4 cell response was greater with LPV/r, and there was less drug resistance associated with virologic failure.<sup>63</sup>
- In the GARDEL study, patients were randomized to 3TC or a 2 NRTI combination, with all study participants receiving LPV/r. The results demonstrated non-inferiority of the two strategies.<sup>88</sup>

#### Adverse Effects:

- In addition to diarrhea, major adverse effects of LPV/r include insulin resistance and hyperlipidemia, especially hypertriglyceridemia; these require pharmacologic management in some patients.
- In the D:A:D and French observational cohorts, cumulative use of LPV/r was associated with a slightly increased risk of MI.<sup>18,24</sup>
- In another D:A:D study, LPV/r use was also reported as an independent predictor of chronic renal impairment.<sup>83</sup>

#### Other Factors and Considerations:

- LPV/r must be boosted with 200 mg/day of RTV and is associated with higher rates of GI side effects and hyperlipidemia than ATV/r and DRV/r, both of which are boosted with 100 mg/day of RTV.
- LPV/r can be given once or twice daily.
- Once-daily dosing should not be used in pregnant women, especially during the third trimester, when LPV levels are expected to decline (see [Perinatal Guidelines](#)).
- LPV/r is currently the only available PI co-formulated with RTV.

#### Panel's Recommendation:

- On the basis of greater potential for adverse events and higher RTV dose and pill burden than ATV/r and DRV/r, the Panel recommends LPV/r plus TDF/FTC or LPV/r plus ABC/3TC as Other regimens **(CI)**.

## ***Other Antiretroviral Regimens for Initial Therapy When Abacavir or Tenofovir Cannot Be Used***

All currently Recommended and Alternative regimens consist of two NRTIs plus a third active drug. This strategy, however, may not be possible or optimal in all patients. In some situations it may be necessary to avoid both TDF and ABC, such as in the case of a patient with pre-existing renal disease who is HLA B\*5701 positive or at high risk of cardiovascular disease.

Based on these concerns, several clinical studies have evaluated strategies using initial regimens that avoid 2 NRTIs or the NRTI drug class altogether. Many of these studies were not fully powered to permit comparisons, and regimens from these studies will not be discussed further. However, there are now sufficient data on two regimens (DRV/r plus RAL and LPV/r plus 3TC) to warrant including them as options when ABC or TDF cannot be used.

### **Darunavir/Ritonavir plus Raltegravir**

In the NEAT/ANRS 143 study, 805 treatment-naïve participants were randomized to receive either twice-daily RAL or once-daily TDF/FTC, both with DRV/r (800 mg/100 mg once daily). At week 96, DRV/r plus RAL was non-inferior to DRV/r plus TDF/FTC based on the primary endpoint of proportion of patients with virologic or clinical failure. Among those with baseline CD4 cell count  $<200/\text{mm}^3$ , however, there were more failures in the two-drug arm; a trend towards more failure was also observed for those with pre-treatment HIV RNA  $\geq 100,000$  copies/mL.<sup>89</sup> High rates of virologic failure in patients with HIV RNA  $>100,000$  copies/mL were also seen in two smaller studies of DRV/r plus RAL.<sup>90,91</sup>

On the basis of these study results, the Panel recommends that DRV/r plus RAL be considered for use only in patients with HIV RNA  $<100,000$  copies/uL and CD4 cell counts  $>200/\text{mm}^3$ , and only in those patients who cannot take either TDF or ABC **(CI)**.

### **Lopinavir/Ritonavir plus Lamivudine**

In the GARDEL study, 426 ART-naïve patients were randomized to receive twice-daily LPV/r plus either open-label 3TC (twice daily) or two NRTIs selected by the study investigators. At 48 weeks, a similar number of patients in each arm had HIV RNA  $<50$  copies/mL, meeting the study's non-inferiority criteria. The LPV/r plus 3TC regimen was better tolerated than the LPV/r plus 2 NRTI regimen.<sup>88</sup>

An important limitation of the GARDEL study is the use of LPV/r, twice daily dosing, and relatively high pill burden (total of 6 tablets per day). LPV/r is not considered a Recommended or Alternative initial PI because of its unfavorable adverse event and pill burden characteristics as compared to pharmacokinetically enhanced ATV and DRV. Given the above limitations, the Panel recommends that LPV/r plus 3TC be considered for use only in patients who cannot take either TDF or ABC **(CI)**.

In summary, the aggregate results from these two fully powered studies with NRTI-limiting regimens demonstrate that these initial strategies have significant deficiencies as compared to standard-of-care treatment approaches, in particular, disadvantages related to pill burden or dosing frequency. In addition, there are concerns about the virologic efficacy of DRV/r plus RAL in patients with high viral loads or low CD4 cell counts. The Panel only recommends LPV/r plus 3TC or DRV/r plus RAL for initial therapy when both TDF and ABC are contraindicated. Other less well-tested NRTI-limiting combinations are not recommended.

**Table 8. Advantages and Disadvantages of Antiretroviral Components Recommended as Initial Antiretroviral Therapy (page 1 of 3)**

**Note:** All drugs within an ARV class are listed in alphabetical order.

ARV Class	ARV Agent(s)	Advantages	Disadvantages
Dual-NRTI	ABC/3TC	<ul style="list-style-type: none"> <li>Co-formulated with DTG as an STR</li> </ul>	<ul style="list-style-type: none"> <li>Inferior virologic responses in patients with baseline HIV RNA <math>\geq 100,000</math> copies/mL when given with EFV or ATV/r as compared with TDF/FTC in ACTG 5202 study. This difference was not seen when ABC/3TC was used in combination with DTG.</li> <li>May cause life-threatening hypersensitivity reaction in patients positive for the HLA B*5701 allele. As a result, HLA-B*5701 testing required before use</li> <li>ABC use has been associated with cardiac events in some but not all observational studies.</li> </ul>
	TDF/FTC	<ul style="list-style-type: none"> <li>Co-formulated with EFV, EVG/c, and RPV as a STR</li> <li>Active against HBV; recommended dual-NRTI for HIV/HBV co-infected patients</li> <li>Better virologic responses than with ABC/3TC in patients with baseline viral load <math>\geq 100,000</math> copies/mL when combined with ATV/r or EFV</li> </ul>	<ul style="list-style-type: none"> <li>Renal toxicity, including proximal tubulopathy and acute or chronic renal insufficiency</li> <li>Decreases BMD more than other NRTI combinations</li> </ul>
INSTI	DTG	<ul style="list-style-type: none"> <li>Once-daily dosing</li> <li>May have higher barrier to resistance than EVG or RAL</li> <li>Co-formulated with ABC and 3TC as an STR</li> <li>No food requirement</li> <li>No CYP3A4 interactions</li> </ul>	<ul style="list-style-type: none"> <li>Oral absorption can be reduced by simultaneous administration with products containing polyvalent cations (e.g., Al, Ca, or Mg-containing antacids or supplements, or multivitamin tablets with minerals). See dosing recommendations in <a href="#">Table 19d</a>.</li> <li>Inhibits renal tubular secretion of Cr and can increase serum Cr, without affecting glomerular function</li> <li>UGT substrate; potential for drug interactions (see <a href="#">Table 19d</a>)</li> </ul>
	EVG/c	<ul style="list-style-type: none"> <li>Co-formulated as a STR with TDF/FTC</li> <li>Once daily dosing</li> <li>Compared with ATV/r, causes smaller increases in total and LDL cholesterol</li> </ul>	<ul style="list-style-type: none"> <li>EVG/c/TDF/FTC is only recommended for patients with baseline CrCl <math>\geq 70</math> mL/min; therapy should be discontinued if CrCl decreases to <math>&lt; 50</math> mL/min.</li> <li>COBI is a potent CYP3A4 inhibitor, which can result in significant interactions with CYP3A substrates.</li> <li>Oral absorption of EVG can be reduced by simultaneous administration with antacids containing polyvalent cations, such as Al, Ca, or Mg (see dosing recommendations in <a href="#">Table 19d</a>).</li> <li>COBI inhibits active tubular secretion of Cr and can increase serum Cr, without affecting renal glomerular function.</li> <li>May have lower genetic barrier to resistance than boosted PI- or DTG-based regimens</li> <li>Food requirement</li> </ul>
	RAL	<ul style="list-style-type: none"> <li>Compared to other INSTIs, has longest post marketing experience</li> <li>No food requirement</li> <li>No CYP3A4 interactions</li> </ul>	<ul style="list-style-type: none"> <li>Twice-daily dosing</li> <li>May have lower genetic barrier to resistance than boosted PI- or DTG-based regimens</li> <li>Increases in creatine kinase, myopathy, and rhabdomyolysis have been reported.</li> <li>Rare cases of severe hypersensitivity reactions (including SJS and TEN) have been reported.</li> <li>Oral absorption of RAL can be significantly impaired by antacids containing Al or Mg; co-administration is not recommended (see dosing recommendations in <a href="#">Table 19d</a>).</li> <li>UGT substrate; potential for drug interactions (see <a href="#">Table 19d</a>)</li> </ul>

**Table 8. Advantages and Disadvantages of Antiretroviral Components Recommended as Initial Antiretroviral Therapy (page 2 of 3)**

ARV Class	ARV Agent(s)	Advantages	Disadvantages
NNRTIs	EFV	<ul style="list-style-type: none"> <li>Once-daily dosing</li> <li>Co-formulated with TDF/FTC</li> <li>Long term clinical experience</li> <li>EFV-based regimens (except for EFV plus ABC/3TC) have well documented efficacy in patients with high HIV RNA</li> </ul>	<ul style="list-style-type: none"> <li>Transmitted resistance more common than with PIs and INSTIs</li> <li>Short- and long-term neuropsychiatric (CNS) side effects, including depression and, in some studies, suicidality</li> <li>Teratogenic in non-human primates; avoid use in women who are trying to conceive or who are sexually active and not using contraception</li> <li>Dyslipidemia</li> <li>Greater risk of resistance at the time of treatment failure than with PIs</li> <li>Skin rash</li> <li>Potential for CYP450 drug interactions (see <a href="#">Tables 18, 19b, and 20a</a>)</li> <li>Should be taken on an empty stomach (food increases drug absorption and CNS toxicities)</li> </ul>
	RPV	<ul style="list-style-type: none"> <li>Once-daily dosing</li> <li>Co-formulated with TDF/FTC</li> <li>Smaller pill size than co-formulated DTG/ABC/3TC, EFV/TDF/FTC, and EVG/c/TDF/FTC</li> <li>Compared with EFV: <ul style="list-style-type: none"> <li>Fewer discontinuations for CNS adverse effects</li> <li>Fewer lipid effects</li> <li>Fewer rashes</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>Not recommended in patients with pre-ART HIV RNA &gt;100,000 copies/mL or CD4 count &lt;200 cells/mm<sup>3</sup> because of higher rate of virologic failure in these patients</li> <li>Transmitted resistance more common than with PIs and INSTIs</li> <li>More NNRTI-, TDF-, and 3TC-associated mutations at virological failure than with regimen containing EFV and two NRTIs</li> <li>Potential for CYP450 drug interactions (see <a href="#">Tables 18, 19b, and 20a</a>)</li> <li>Meal requirement (&gt;390 kcal)</li> <li>Requires acid for adequate absorption <ul style="list-style-type: none"> <li>Contraindicated with PPIs</li> <li>Use with H<sub>2</sub> antagonists or antacids with caution (see <a href="#">Table 19a</a> for detailed dosing information).</li> </ul> </li> <li>Use with caution when coadministered with a drug known to increase the risk of torsades de pointes.</li> </ul>
PIs	ATV/c or ATV/r	<ul style="list-style-type: none"> <li>Once-daily dosing</li> <li>Higher genetic barrier to resistance than NNRTIs, EVG, and RAL</li> <li>PI resistance at the time of treatment failure uncommon with pharmacologically-boosted PIs</li> <li>ATV/c and ATV/r have similar virologic activity and toxicity profiles</li> </ul>	<ul style="list-style-type: none"> <li>Commonly causes indirect hyperbilirubinemia, which may manifest as scleral icterus or jaundice</li> <li>Food requirement</li> <li>Absorption depends on food and low gastric pH (see <a href="#">Table 19a</a> for interactions with H<sub>2</sub> antagonists, antacids, and PPIs)</li> <li>Nephrolithiasis, cholelithiasis, nephrotoxicity</li> <li>GI adverse effects</li> <li>CYP3A4 inhibitors and substrates: potential for drug interactions (see <a href="#">Tables 18 and 19a</a>)</li> </ul>
	ATV/c-specific considerations	<ul style="list-style-type: none"> <li>Co-formulated tablet</li> </ul>	<ul style="list-style-type: none"> <li>COBI inhibits active tubular secretion of Cr and can increase serum Cr, without affecting renal glomerular function</li> <li>Coadministration with TDF is not recommended in patients with CrCl &lt;70 mL/min</li> <li>Less long term clinical experience than for ATV/r</li> <li>COBI is a potent CYP3A4 inhibitor, which can result in significant interactions with CYP3A substrates.</li> </ul>



**Table 8. Advantages and Disadvantages of Antiretroviral Components Recommended as Initial Antiretroviral Therapy (page 3 of 3)**

ARV Class	ARV Agent(s)	Advantages	Disadvantages
PIs	DRV/c or DRV/r	<ul style="list-style-type: none"> <li>Once-daily dosing</li> <li>Higher genetic barrier to resistance than NNRTIs, EVG, and RAL</li> <li>PI resistance at the time of treatment failure uncommon with pharmacokinetically-boosted PIs</li> </ul>	<ul style="list-style-type: none"> <li>Skin rash</li> <li>Food requirement</li> <li>GI adverse effects</li> <li>CYP3A4 inhibitors and substrates: potential for drug interactions (see <a href="#">Tables 18 and 19a</a>)</li> </ul>
	DRV/c-specific considerations	<ul style="list-style-type: none"> <li>Co-formulated tablet</li> </ul>	<ul style="list-style-type: none"> <li>Less long-term clinical experience than for DRV/r</li> <li>COBI inhibits active tubular secretion of Cr and can increase serum Cr, without affecting renal glomerular function</li> <li>Co-administration with TDF is not recommended in patients with CrCl &lt;70 mL/min</li> <li>Approval primarily based on pharmacokinetic data comparable to that for DRV/r rather than on trials comparing the efficacy of DRV/c and DRV/r</li> <li>COBI is a potent CYP3A4 inhibitor, which can result in significant interactions with CYP3A substrates.</li> </ul>
	LPV/r	<ul style="list-style-type: none"> <li>Only RTV-coformulated PI</li> <li>No food requirement</li> <li>Once or twice daily dosing</li> </ul>	<ul style="list-style-type: none"> <li>Requires 200 mg per day of RTV</li> <li>Once-daily dosing not recommended in pregnant women</li> <li>Possible higher risk of MI associated with cumulative use of LPV/r</li> <li>PR and QT interval prolongation have been reported. Use with caution in patients at risk of cardiac conduction abnormalities or receiving other drugs with similar effect</li> <li>Possible nephrotoxicity</li> <li>CYP3A4 inhibitors and substrates: potential for drug interactions (see <a href="#">Tables 18 and 19a</a>)</li> </ul>

**Key to Acronyms:** 3TC = lamivudine; ABC = abacavir; ART = antiretroviral therapy; Al = aluminum; ARV = antiretroviral; ATV = atazanavir; ATV/c = cobicistat-boosted atazanavir; ATV/r = ritonavir-boosted atazanavir; BMD = bone mineral density; Ca = calcium; CaCO<sub>3</sub> = calcium carbonate; CNS = central nervous system; COBI = cobicistat; Cr = creatinine; CrCl = creatinine clearance; CYP = cytochrome P; DRV/c = cobicistat-boosted darunavir; DRV/r = ritonavir-boosted darunavir; DTG = dolutegravir; EFV = efavirenz; EVG = elvitegravir; FTC = emtricitabine; GI = gastrointestinal; HBV = hepatitis B virus; HSR = hypersensitivity reaction; INSTI = integrase strand transfer inhibitor; LPV/r = ritonavir-boosted lopinavir; Mg = magnesium; MI = myocardial infarction; NNRTI = non-nucleoside reverse transcriptase inhibitor; NRTI = nucleoside reverse transcriptase inhibitor; PI = protease inhibitor; PPI = proton pump inhibitor; RAL = raltegravir; RPV = rilpivirine; RTV = ritonavir; SJS = Stevens-Johnson syndrome; STR = single tablet regimen; TDF = tenofovir disoproxil fumarate; TEN = toxic epidermal necrosis

**Table 9. Antiretroviral Components or Regimens Not Recommended as Initial Therapy (page 1 of 2)**

ARV Drugs or Components	Reasons for <u>Not</u> Recommending as Initial Therapy
<b>NRTIs</b>	
<b>ABC/3TC/ZDV (Co-Formulated)</b> As triple-NRTI combination regimen	<ul style="list-style-type: none"> <li>• Inferior virologic efficacy</li> </ul>
<b>ABC plus 3TC plus ZDV plus TDF</b> As quadruple-NRTI combination regimen	<ul style="list-style-type: none"> <li>• Inferior virologic efficacy</li> </ul>
<b>d4T plus 3TC</b>	<ul style="list-style-type: none"> <li>• Significant toxicities including lipodystrophy; peripheral neuropathy; and hyperlactatemia, including symptomatic and life-threatening lactic acidosis, hepatic steatosis, and pancreatitis</li> </ul>
<b>ddI plus 3TC (or FTC)</b>	<ul style="list-style-type: none"> <li>• Inferior virologic efficacy</li> <li>• Limited clinical trial experience in ART-naïve patients</li> <li>• ddI toxicities such as pancreatitis, peripheral neuropathy</li> </ul>
<b>ddI plus TDF</b>	<ul style="list-style-type: none"> <li>• High rate of early virologic failure</li> <li>• Rapid selection of resistance mutations</li> <li>• Potential for immunologic nonresponse/CD4 cell decline</li> <li>• Increased ddI drug exposure and toxicities</li> </ul>
<b>ZDV/3TC</b>	<ul style="list-style-type: none"> <li>• ZDV/3TC is generally not recommended as initial therapy because greater toxicities (including bone marrow suppression; GI toxicities; and mitochondrial toxicities such as lipodystrophy, lactic acidosis, and hepatic steatosis; skeletal muscle myopathy; and cardiomyopathy) than Recommended NRTIs.</li> </ul>
<b>NNRTIs</b>	
<b>DLV</b>	<ul style="list-style-type: none"> <li>• Inferior virologic efficacy</li> <li>• Inconvenient (three times daily) dosing</li> </ul>
<b>ETR</b>	<ul style="list-style-type: none"> <li>• Insufficient data in ART-naïve patients</li> </ul>
<b>NVP</b>	<ul style="list-style-type: none"> <li>• Associated with serious and potentially fatal toxicity (hepatic events, severe rash, including SJS and TEN)</li> <li>• When compared to EFV, NVP did not meet non-inferiority criteria</li> </ul>
<b>PIs</b>	
<b>ATV (Unboosted)</b>	<ul style="list-style-type: none"> <li>• Less potent than boosted ATV</li> </ul>
<b>DRV (Unboosted)</b>	<ul style="list-style-type: none"> <li>• Use without RTV has not been studied</li> </ul>
<b>FPV (Unboosted)</b> or <b>FPV/r</b>	<ul style="list-style-type: none"> <li>• Virologic failure with unboosted FPV-based regimen may result in selection of mutations that confer resistance to FPV and DRV.</li> <li>• Less clinical trial data for FPV/r than for other PI/r</li> </ul>
<b>IDV (Unboosted)</b>	<ul style="list-style-type: none"> <li>• Inconvenient dosing (three times daily with meal restrictions)</li> <li>• Fluid requirement</li> <li>• IDV toxicities such as nephrolithiasis, crystalluria</li> </ul>
<b>IDV/r</b>	<ul style="list-style-type: none"> <li>• Fluid requirement</li> <li>• IDV toxicities such as nephrolithiasis, crystalluria</li> </ul>
<b>NFV</b>	<ul style="list-style-type: none"> <li>• Inferior virologic efficacy</li> <li>• Diarrhea</li> </ul>

**Table 9. Antiretroviral Components or Regimens Not Recommended as Initial Therapy (page 2 of 2)**

ARV Drugs or Components	Reasons for <u>Not</u> Recommending as Initial Therapy
RTV as sole PI	<ul style="list-style-type: none"> <li>• High pill burden</li> <li>• GI intolerance</li> <li>• Metabolic toxicity</li> </ul>
SQV (Unboosted)	<ul style="list-style-type: none"> <li>• Inadequate bioavailability</li> <li>• Inferior virologic efficacy</li> </ul>
SQV/r	<ul style="list-style-type: none"> <li>• High pill burden</li> <li>• Can cause QT and PR prolongation; requires pre-treatment and follow-up ECG</li> </ul>
TPV/r	<ul style="list-style-type: none"> <li>• Inferior virologic efficacy</li> <li>• Higher rate of adverse events than other RTV-boosted PIs</li> <li>• Higher dose of RTV required for boosting than other RTV-boosted PIs</li> </ul>
<b>CCR5 Anagonist</b>	
MVC	<ul style="list-style-type: none"> <li>• Requires testing for CCR5 tropism before initiation of therapy</li> <li>• No virologic benefit when compared with other recommended regimens</li> <li>• Requires twice-daily dosing</li> </ul>

**Key to Acronyms:** 3TC = lamivudine; ABC = abacavir; ART = antiretroviral therapy; ARV = antiretroviral; ATV = atazanavir; d4T = stavudine; ddI = didanosine; DLV = delavirdine; DRV = darunavir; ETR = etravirine; FPV = fosamprenavir; FPV/r = ritonavir-boosted fosamprenavir; FTC = emtricitabine; GI = gastrointestinal; IDV = indinavir; MVC = maraviroc; NFV = nelfinavir; NVP = nevirapine; NRTI = nucleoside reverse transcriptase inhibitor; PI = protease inhibitor; RTV = ritonavir; SJS = Stevens Johnson Syndrome; SQV = saquinavir; SQV/r = ritonavir-boosted saquinavir; TDF = tenofovir disoproxil fumarate; TEN = toxic epidermal necrolysis; TPV = tipranavir; ZDV = zidovudine

## References

1. Moore RD, Bartlett JG. Dramatic decline in the HIV-1 RNA level over calendar time in a large urban HIV practice. *Clin Infect Dis*. 2011;53(6):600-604. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21844006>.
2. Gill VS, Lima VD, Zhang W, et al. Improved virological outcomes in British Columbia concomitant with decreasing incidence of HIV type 1 drug resistance detection. *Clin Infect Dis*. 2010;50(1):98-105. Available at <http://www.ncbi.nlm.nih.gov/pubmed/19951169>.
3. Lee FJ, Amin J, Carr A. Efficacy of initial antiretroviral therapy for HIV-1 infection in adults: a systematic review and meta-analysis of 114 studies with up to 144 weeks' follow-up. *PLoS One*. 2014;9(5):e97482. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24830290>.
4. Lennox JL, Landovitz RJ, Ribaud HJ, et al. Efficacy and tolerability of 3 nonnucleoside reverse transcriptase inhibitor-sparing antiretroviral regimens for treatment-naïve volunteers infected with HIV-1: a randomized, controlled equivalence trial. *Ann Intern Med*. 2014;161(7):461-471. Available at <http://www.ncbi.nlm.nih.gov/pubmed/25285539>.
5. Mollan KR, Smurzynski M, Eron JJ, et al. Association between efavirenz as initial therapy for HIV-1 infection and increased risk for suicidal ideation or attempted or completed suicide: an analysis of trial data. *Ann Intern Med*. 2014;161(1):1-10. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24979445>.
6. Clotet B, Feinberg J, van Lunzen J, et al. Once-daily dolutegravir versus darunavir plus ritonavir in antiretroviral-naïve adults with HIV-1 infection (FLAMINGO): 48 week results from the randomised open-label phase 3b study. *Lancet*. 2014. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24698485>.
7. Sax P, Tierney C, Collier AC, et al. Abacavir-lamivudine versus tenofovir-emtricitabine for initial HIV-1 therapy. *N Engl J Med*. 2009;361. DOI: 10.1056/NEJMoa0906768.
8. Post FA, Moyle GJ, Stellbrink HJ, et al. Randomized comparison of renal effects, efficacy, and safety with once-daily abacavir/lamivudine versus tenofovir/emtricitabine, administered with efavirenz, in antiretroviral-naïve, HIV-1-infected

adults: 48-week results from the ASSERT study. *J Acquir Immune Defic Syndr*. 2010;55(1):49-57. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=20431394](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20431394).

9. Smith KY, Patel P, Fine D, et al. Randomized, double-blind, placebo-matched, multicenter trial of abacavir/lamivudine or tenofovir/emtricitabine with lopinavir/ritonavir for initial HIV treatment. *AIDS*. 2009;23(12):1547-1556. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19542866](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19542866).
10. Walmsley SL, Antela A, Clumeck N, et al. Dolutegravir plus abacavir-lamivudine for the treatment of HIV-1 infection. *N Engl J Med*. 2013;369(19):1807-1818. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24195548>.
11. Sax PE, Tierney C, Collier AC, et al. Abacavir/lamivudine versus tenofovir DF/emtricitabine as part of combination regimens for initial treatment of HIV: final results. *J Infect Dis*. 2011;204(8):1191-1201. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=21917892](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=21917892).
12. DeJesus E, Herrera G, Teofilo E, et al. Abacavir versus zidovudine combined with lamivudine and efavirenz, for the treatment of antiretroviral-naïve HIV-infected adults. *Clin Infect Dis*. 2004;39(7):1038-1046. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=15472858](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15472858).
13. Rodriguez-French A, Boghossian J, Gray GE, et al. The NEAT study: a 48-week open-label study to compare the antiviral efficacy and safety of GW433908 versus nelfinavir in antiretroviral therapy-naïve HIV-1-infected patients. *J Acquir Immune Defic Syndr*. 2004;35(1):22-32. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=14707788](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=14707788).
14. Gathe JC, Jr., Ive P, Wood R, et al. SOLO: 48-week efficacy and safety comparison of once-daily fosamprenavir/ritonavir versus twice-daily nelfinavir in naïve HIV-1-infected patients. *AIDS*. 2004;18(11):1529-1537. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=15238771](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15238771).
15. Saag M, Balu R, Phillips E, et al. High sensitivity of human leukocyte antigen-b\*5701 as a marker for immunologically confirmed abacavir hypersensitivity in white and black patients. *Clin Infect Dis*. 2008;46(7):1111-1118. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18444831](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18444831).
16. Mallal S, Phillips E, Carosi G, et al. HLA-B\*5701 screening for hypersensitivity to abacavir. *N Engl J Med*. 2008;358(6):568-579. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18256392](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18256392).
17. Sabin CA, Worm SW, Weber R, et al. Use of nucleoside reverse transcriptase inhibitors and risk of myocardial infarction in HIV-infected patients enrolled in the D:A:D study: a multi-cohort collaboration. *Lancet*. 2008;371(9622):1417-1426. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18387667](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18387667).
18. Worm SW, Sabin C, Weber R, et al. Risk of myocardial infarction in patients with HIV infection exposed to specific individual antiretroviral drugs from the 3 major drug classes: the data collection on adverse events of anti-HIV drugs (D:A:D) study. *J Infect Dis*. 2010;201(3):318-330. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=20039804](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20039804).
19. The SMART/INSIGHT and the D:A:D Study Groups; TSI at DADSG. Use of nucleoside reverse transcriptase inhibitors and risk of myocardial infarction in HIV-infected patients. *AIDS*. 2008;22(14):F17-24. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18753925](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18753925).
20. Obel N, Farkas DK, Kronborg G, et al. Abacavir and risk of myocardial infarction in HIV-infected patients on highly active antiretroviral therapy: a population-based nationwide cohort study. *HIV Med*. 2010;11(2):130-136. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19682101](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19682101).
21. Choi AI, Vittinghoff E, Deeks SG, Weekley CC, Li Y, Shlipak MG. Cardiovascular risks associated with abacavir and tenofovir exposure in HIV-infected persons. *AIDS*. 2011;25(10):1289-1298. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=21516027](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=21516027).
22. Durand M, Sheehy O, Baril JG, Leloir J, Tremblay CL. Association between HIV infection, antiretroviral therapy, and risk of acute myocardial infarction: a cohort and nested case-control study using Quebec's public health insurance database. *J Acquir Immune Defic Syndr*. 2011;57(3):245-253. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=21499115](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=21499115).
23. Brothers CH, Hernandez JE, Cutrell AG, et al. Risk of myocardial infarction and abacavir therapy: no increased risk across 52 GlaxoSmithKline-sponsored clinical trials in adult subjects. *J Acquir Immune Defic Syndr*. 2009;51(1):20-28. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19282778](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19282778).
24. Lang S, Mary-Krause M, Cotte L, et al. Impact of individual antiretroviral drugs on the risk of myocardial infarction in

human immunodeficiency virus-infected patients: a case-control study nested within the French Hospital Database on HIV ANRS cohort CO4. *Arch Intern Med*. 2010;170(14):1228-1238. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=20660842](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20660842).

25. Bedimo RJ, Westfall AO, Drechsler H, Vidiella G, Tebas P. Abacavir use and risk of acute myocardial infarction and cerebrovascular events in the highly active antiretroviral therapy era. *Clin Infect Dis*. 2011;53(1):84-91. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=21653308](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=21653308).
26. Ribaud HJ, Benson CA, Zheng Y, et al. No risk of myocardial infarction associated with initial antiretroviral treatment containing abacavir: short and long-term results from ACTG A5001/ALLRT. *Clin Infect Dis*. 2011;52(7):929-940. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=21427402](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=21427402).
27. Ding X, Andraca-Carrera E, Cooper C, et al. No association of abacavir use with myocardial infarction: findings of an FDA meta-analysis. *J Acquir Immune Defic Syndr*. 2012;61(4):441-447. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22932321>.
28. Cassetti I, Madruga JV, Etzel A, et al. The safety and efficacy of tenofovir DF (TDF) in combination with lamivudine (3TC) and efavirenz (EFV) in antiretroviral-naïve patients through seven years. Presented at: 17th International AIDS Conference. 2008. Mexico City, Mexico.
29. Molina JM, Podszadecki TJ, Johnson MA, et al. A lopinavir/ritonavir-based once-daily regimen results in better compliance and is non-inferior to a twice-daily regimen through 96 weeks. *AIDS Res Hum Retroviruses*. 2007;23(12):1505-1514. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18160008](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18160008).
30. Molina JM, Andrade-Villanueva J, Echevarria J, et al. Once-daily atazanavir/ritonavir versus twice-daily lopinavir/ritonavir, each in combination with tenofovir and emtricitabine, for management of antiretroviral-naïve HIV-1-infected patients: 48 week efficacy and safety results of the CASTLE study. *Lancet*. 2008;372(9639):646-655. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18722869](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18722869).
31. Ortiz R, DeJesus E, Khanlou H, et al. Efficacy and safety of once-daily darunavir/ritonavir versus lopinavir/ritonavir in treatment-naïve HIV-1-infected patients at week 48. *AIDS*. 2008;22(12):1389-1397. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18614861](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18614861).
32. Smith KY, Weinberg WG, DeJesus E, et al. Fosamprenavir or atazanavir once daily boosted with ritonavir 100 mg, plus tenofovir/emtricitabine, for the initial treatment of HIV infection: 48-week results of ALERT. *AIDS Res Ther*. 2008;5:5. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18373851](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18373851).
33. Lennox JL, DeJesus E, Lazzarin A, et al. Safety and efficacy of raltegravir-based versus efavirenz-based combination therapy in treatment-naïve patients with HIV-1 infection: a multicentre, double-blind randomised controlled trial. *Lancet*. 2009;374(9692):796-806. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19647866](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19647866).
34. DeJesus E, Rockstroh JK, Henry K, et al. Co-formulated elvitegravir, cobicistat, emtricitabine, and tenofovir disoproxil fumarate versus ritonavir-boosted atazanavir plus co-formulated emtricitabine and tenofovir disoproxil fumarate for initial treatment of HIV-1 infection: a randomised, double-blind, phase 3, non-inferiority trial. *Lancet*. 2012;379(9835):2429-2438. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22748590>.
35. Sax PE, DeJesus E, Mills A, et al. Co-formulated elvitegravir, cobicistat, emtricitabine, and tenofovir versus co-formulated efavirenz, emtricitabine, and tenofovir for initial treatment of HIV-1 infection: a randomised, double-blind, phase 3 trial, analysis of results after 48 weeks. *Lancet*. 2012;379(9835):2439-2448. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22748591>.
36. DeJesus E, Rockstroh JK, Lennox JL, et al. Efficacy of raltegravir versus efavirenz when combined with tenofovir/emtricitabine in treatment-naïve HIV-1-infected patients: week-192 overall and subgroup analyses from STARTMRK. *HIV Clin Trials*. 2012;13(4):228-232. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22849964>.
37. Raffi F, Jaeger H, Quiros-Roldan E, et al. Once-daily dolutegravir versus twice-daily raltegravir in antiretroviral-naïve adults with HIV-1 infection (SPRING-2 study): 96 week results from a randomised, double-blind, non-inferiority trial. *Lancet Infect Dis*. 2013;13(11):927-935. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24074642>.
38. Karras A, Lafaurie M, Furco A, et al. Tenofovir-related nephrotoxicity in human immunodeficiency virus-infected patients: three cases of renal failure, Fanconi syndrome, and nephrogenic diabetes insipidus. *Clin Infect Dis*. 2003;36(8):1070-1073. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=12684922](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=12684922).



39. Zimmermann AE, Pizzoferrato T, Bedford J, Morris A, Hoffman R, Braden G. Tenofovir-associated acute and chronic kidney disease: a case of multiple drug interactions. *Clin Infect Dis*. 2006;42(2):283-290. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=16355343](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16355343).
40. Gervasoni C, Meraviglia P, Landonio S, et al. Low body weight in females is a risk factor for increased tenofovir exposure and drug-related adverse events. *PLoS One*. 2013;8(12):e80242. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24312465>.
41. Moore R, Keruly J, Gallant J. Tenofovir and renal dysfunction in clinical practice. Presented at 14th Conference on Retrovirus and Opportunistic Infections; February 25-28, 2007; Los Angeles, CA.
42. Kearney BP, Mathias A, Mittan A, Sayre J, Ebrahimi R, Cheng AK. Pharmacokinetics and safety of tenofovir disoproxil fumarate on coadministration with lopinavir/ritonavir. *J Acquir Immune Defic Syndr*. 2006;43(3):278-283. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17079992](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17079992).
43. Goicoechea M, Liu S, Best B, et al. Greater tenofovir-associated renal function decline with protease inhibitor-based versus nonnucleoside reverse-transcriptase inhibitor-based therapy. *J Infect Dis*. 2008;197(1):102-108. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18171292](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18171292).
44. Kiser JJ, Carten ML, Aquilante CL, et al. The effect of lopinavir/ritonavir on the renal clearance of tenofovir in HIV-infected patients. *Clin Pharmacol Ther*. 2008;83(2):265-272. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17597712](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17597712).
45. Gallant JE, Moore RD. Renal function with use of a tenofovir-containing initial antiretroviral regimen. *AIDS*. 2009;23(15):1971-1975. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19696652](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19696652).
46. Stribild [package insert]. Food and Drug Administration. 2013. Available at [http://www.accessdata.fda.gov/drugsatfda\\_docs/label/2013/203100s009lbl.pdf](http://www.accessdata.fda.gov/drugsatfda_docs/label/2013/203100s009lbl.pdf). Accessed January 22, 2016.
47. Stellbrink HJ, Orkin C, Arribas JR, et al. Comparison of changes in bone density and turnover with abacavir-lamivudine versus tenofovir-emtricitabine in HIV-infected adults: 48-week results from the ASSERT study. *Clin Infect Dis*. 2010;51(8):963-972. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=20828304](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20828304).
48. McComsey GA, Kitch D, Daar ES, et al. Bone mineral density and fractures in antiretroviral-naïve persons randomized to receive abacavir-lamivudine or tenofovir disoproxil fumarate-emtricitabine along with efavirenz or atazanavir-ritonavir: Aids Clinical Trials Group A5224s, a substudy of ACTG A5202. *J Infect Dis*. 2011;203(12):1791-1801. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=21606537](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=21606537).
49. Perrot S, Aslangul E, Szwebel T, Caillat-Vigneron N, Le Jeune C. Bone pain due to fractures revealing osteomalacia related to tenofovir-induced proximal renal tubular dysfunction in a human immunodeficiency virus-infected patient. *J Clin Rheumatol*. 2009;15(2):72-74. Available at <http://www.ncbi.nlm.nih.gov/pubmed/19265350>.
50. Lucas GM, Ross MJ, Stock PG, et al. Clinical practice guideline for the management of chronic kidney disease in patients infected with HIV: 2014 update by the HIV Medicine Association of the Infectious Diseases Society of America. *Clin Infect Dis*. 2014;59(9):e96-138. Available at <http://www.ncbi.nlm.nih.gov/pubmed/25234519>.
51. Pappa K, Baumgarten A, Felizarta F, et al. Dolutegravir (DTG) + abacavir/lamivudine once daily superior to tenofovir/emtricitabine/efavirenz in treatment naïve HIV Subjects: 144-week results from SINGLE (ING114467). Presented at: Interscience Conference on Antimicrobial Agents and Chemotherapy. 2014. Washington D.C.
52. Feinberg J, Clotet B, Khuong-Josses MA, et al. Once-daily dolutegravir (DTG) is superior to darunavir/ritonavir (DRV/r) in antiretroviral-naïve adults: 48 week results from FLAMINGO (ING114915). Presented at: 53rd Interscience Conference on Antimicrobial Agents and Chemotherapy. 2013. Denver, CO.
53. Molina JM, Clotet B, van Lunzen J, et al. Once-daily dolutegravir is superior to once-daily darunavir/ritonavir in treatment-naïve HIV-1-positive individuals: 96 week results from FLAMINGO. *J Int AIDS Soc*. 2014;17(4 Suppl 3):19490. Available at <http://www.ncbi.nlm.nih.gov/pubmed/25393999>.
54. Wohl DA, Cohen C, Gallant JE, et al. A randomized, double-blind comparison of single-tablet regimen elvitegravir/cobicistat/emtricitabine/tenofovir DF versus single-tablet regimen efavirenz/emtricitabine/tenofovir DF for initial treatment of HIV-1 infection: analysis of week 144 results. *J Acquir Immune Defic Syndr*. 2014;65(3):e118-120. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24256630>.
55. Clumeck N, Molina J, Henry K, Gathe J, et al. Elvitegravir/cobicistat/emtricitabine/tenofovir DF (STB) has durable efficacy and differentiated safety compared to atazanavir boosted by ritonavir plus emtricitabine/tenofovir DF at week



- 144 in treatment-naïve HIV-1 infected patients. Abs LBPS7/2. Presented at: 14th European AIDS Conference. 2013. Brussels, Belgium.
56. Mathias AA, West S, Hui J, Kearney BP. Dose-response of ritonavir on hepatic CYP3A activity and elvitegravir oral exposure. *Clin Pharmacol Ther.* 2009;85(1):64-70. Available at <http://www.ncbi.nlm.nih.gov/pubmed/18815591>.
  57. German P, Liu HC, Szwarcberg J, et al. Effect of cobicistat on glomerular filtration rate in subjects with normal and impaired renal function. *J Acquir Immune Defic Syndr.* 2012;61(1):32-40. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22732469>.
  58. Rockstroh JK, DeJesus E, Lennox JL, et al. Durable efficacy and safety of raltegravir versus efavirenz when combined with tenofovir/emtricitabine in treatment-naïve HIV-1-infected patients: final 5-year results from STARTMRK. *J Acquir Immune Defic Syndr.* 2013;63(1):77-85. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23412015>.
  59. Isentress [package insert]. Food and Drug Administration. 2014. Available at <http://www.accessdata.fda.gov/scripts/cder/drugsatfda/index.cfm?fuseaction=Search.Overview&DrugName=ISENTRESS&CFID=23260658&CFTOKEN=7a9d32074acb2921-F7406A7E-96B4-5EF1-32E62C6D79A47CCF>. Accessed January 22, 2016.
  60. Snedecor SJ, Khachatryan A, Nedrow K, et al. The prevalence of transmitted resistance to first-generation non-nucleoside reverse transcriptase inhibitors and its potential economic impact in HIV-infected patients. *PLoS One.* 2013;8(8):e72784. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23991151>.
  61. Cohen CJ, Molina JM, Cahn P, et al. Efficacy and safety of rilpivirine (TMC278) versus efavirenz at 48 weeks in treatment-naïve HIV-1-infected patients: pooled results from the phase 3 double-blind randomized ECHO and THRIVE Trials. *J Acquir Immune Defic Syndr.* 2012;60(1):33-42. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22343174>.
  62. Edurant [package insert]. Food and Drug Administration. 2013. [http://www.accessdata.fda.gov/drugsatfda\\_docs/label/2013/202022s0051b1.pdf](http://www.accessdata.fda.gov/drugsatfda_docs/label/2013/202022s0051b1.pdf) Accessed January 22, 2016.
  63. Riddler SA, Haubrich R, DiRienzo AG, et al. Class-sparing regimens for initial treatment of HIV-1 infection. *N Engl J Med.* 2008;358(20):2095-2106. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18480202](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18480202).
  64. van Leth F, Phanuphak P, Ruxrungtham K, et al. Comparison of first-line antiretroviral therapy with regimens including nevirapine, efavirenz, or both drugs, plus stavudine and lamivudine: a randomised open-label trial, the 2NN Study. *Lancet.* 2004;363(9417):1253-1263. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=15094269](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15094269).
  65. Daar ES, Tierney C, Fischl MA, et al. Atazanavir plus ritonavir or efavirenz as part of a 3-drug regimen for initial treatment of HIV-1. *Ann Intern Med.* 2011;154(7):445-456. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21320923>.
  66. Cohen CJ, Molina JM, Cassetti I, et al. Week 96 efficacy and safety of rilpivirine in treatment-naïve, HIV-1 patients in two Phase III randomized trials. *AIDS.* 2013;27(6):939-950. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23211772>.
  67. Cohen C, Wohl D, Arribas JR, et al. Week 48 results from a randomized clinical trial of rilpivirine/emtricitabine/tenofovir disoproxil fumarate vs. efavirenz/emtricitabine/tenofovir disoproxil fumarate in treatment-naïve HIV-1-infected adults. *AIDS.* 2014;28(7):989-997. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24508782>.
  68. Group ES. Efficacy of 400 mg efavirenz versus standard 600 mg dose in HIV-infected, antiretroviral-naïve adults (ENCORE1): a randomised, double-blind, placebo-controlled, non-inferiority trial. *Lancet.* 2014. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24522178>.
  69. Smith C, Ryom L, Monforte A, et al. Lack of association between use of efavirenz and death from suicide: evidence from the D:A:D study. *J Int AIDS Soc.* 2014;17(4 Suppl 3):19512. Available at <http://www.ncbi.nlm.nih.gov/pubmed/25394021>.
  70. Napoli AA, Wood JJ, Coumbis JJ, Soitkar AM, Seekins DW, Tilson HH. No evident association between efavirenz use and suicidality was identified from a disproportionality analysis using the FAERS database. *J Int AIDS Soc.* 2014;17:19214. Available at <http://www.ncbi.nlm.nih.gov/pubmed/25192857>.
  71. Fundaro C, Genovese O, Rendeli C, Tamburrini E, Salvaggio E. Myelomeningocele in a child with intrauterine exposure to efavirenz. *AIDS.* 2002;16(2):299-300. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=11807320](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11807320).
  72. Lathouwers E, De Meyer S, Dierynck I, et al. Virological characterization of patients failing darunavir/ritonavir or lopinavir/ritonavir treatment in the ARTEMIS study: 96-week analysis. *Antivir Ther.* 2011;16(1):99-108. Available at

[http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=21311113](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=21311113).

73. Soriano V, Arasteh K, Migrone H, et al. Nevirapine versus atazanavir/ritonavir, each combined with tenofovir disoproxil fumarate/emtricitabine, in antiretroviral-naïve HIV-1 patients: the ARTEN Trial. *Antivir Ther*. 2011;16(3):339-348. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=21555816](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=21555816).
74. Monforte AD, Reiss P, Ryom L, et al. Atazanavir is not associated with an increased risk of cardio or cerebrovascular disease events. *AIDS*. 2013;27(3):407-415. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23291539>.
75. Orkin C, Dejesus E, Khanlou H, et al. Final 192-week efficacy and safety of once-daily darunavir/ritonavir compared with lopinavir/ritonavir in HIV-1-infected treatment-naïve patients in the ARTEMIS trial. *HIV Med*. 2013;14(1):49-59. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23088336>.
76. Trottier B, Machouf N, Thomas R, et al. Abacavir/lamivudine fixed-dose combination with ritonavir-boosted darunavir: a safe and efficacious regimen for HIV therapy. *HIV Clin Trials*. 2012;13(6):335-342. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23195671>.
77. Molina JM, Andrade-Villanueva J, Echevarria J, et al. Once-daily atazanavir/ritonavir compared with twice-daily lopinavir/ritonavir, each in combination with tenofovir and emtricitabine, for management of antiretroviral-naïve HIV-1-infected patients: 96-week efficacy and safety results of the CASTLE study. *J Acquir Immune Defic Syndr*. 2010;53(3):323-332. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=20032785](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20032785).
78. Smith KY, Tierney C, Mollan K, et al. Outcomes by sex following treatment initiation with atazanavir plus ritonavir or efavirenz with abacavir/lamivudine or tenofovir/emtricitabine. *Clin Infect Dis*. 2014;58(4):555-563. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24253247>.
79. Gallant JE, Koenig E, Andrade-Villanueva J, et al. Cobicistat versus ritonavir as a pharmacoenhancer of atazanavir plus emtricitabine/tenofovir disoproxil fumarate in treatment-naïve HIV type 1-infected patients: week 48 results. *J Infect Dis*. 2013;208(1):32-39. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23532097>.
80. Chan-Tack KM, Truffa MM, Struble KA, Birnkrant DB. Atazanavir-associated nephrolithiasis: cases from the U.S. Food and Drug Administration's Adverse Event Reporting System. *AIDS*. 2007;21(9):1215-1218. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17502736](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17502736).
81. Rockwood N, Mandalia S, Bower M, Gazzard B, Nelson M. Ritonavir-boosted atazanavir exposure is associated with an increased rate of renal stones compared with efavirenz, ritonavir-boosted lopinavir and ritonavir-boosted darunavir. *AIDS*. 2011;25(13):1671-1673. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21716074>.
82. Hamada Y, Nishijima T, Watanabe K, et al. High incidence of renal stones among HIV-infected patients on ritonavir-boosted atazanavir than in those receiving other protease inhibitor-containing antiretroviral therapy. *Clin Infect Dis*. 2012;55(9):1262-1269. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22820542>.
83. Ryom L, Mocroft A, Kirk O, et al. Association between antiretroviral exposure and renal impairment among HIV-positive persons with normal baseline renal function: the D:A:D study. *J Infect Dis*. 2013;207(9):1359-1369. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23382571>.
84. Rakotondravelo S, Poincignon Y, Borsa-Lebas F, et al. Complicated atazanavir-associated cholelithiasis: a report of 14 cases. *Clin Infect Dis*. 2012;55(9):1270-1272. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22820540>.
85. Tybost [package insert]. Food and Drug Administration. 2014. Available at [http://www.accessdata.fda.gov/drugsatfda\\_docs/label/2014/203094s000lbl.pdf](http://www.accessdata.fda.gov/drugsatfda_docs/label/2014/203094s000lbl.pdf). Accessed January 22, 2016.
86. Tashima K, Crofoot G, Tomaka FL, et al. Phase IIIb, open-label single-arm trial of darunavir/cobicistat (DRV/COBI): Week 48 subgroup analysis of HIV-1-infected treatment-naïve adults. *J Int AIDS Soc*. 2014;17(4 Suppl 3):19772. Available at <http://www.ncbi.nlm.nih.gov/pubmed/25397516>.
87. Murphy RL, da Silva BA, Hicks CB, et al. Seven-year efficacy of a lopinavir/ritonavir-based regimen in antiretroviral-naïve HIV-1-infected patients. *HIV Clin Trials*. 2008;9(1):1-10. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18215977](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18215977).
88. Cahn P, Andrade-Villanueva J, Arribas JR, et al. Dual therapy with lopinavir and ritonavir plus lamivudine versus triple therapy with lopinavir and ritonavir plus two nucleoside reverse transcriptase inhibitors in antiretroviral-therapy-naïve adults with HIV-1 infection: 48 week results of the randomised, open label, non-inferiority GARDEL trial. *Lancet Infect Dis*. 2014;14(7):572-580. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24783988>.
89. Raffi F, Babiker AG, Richert L, et al. Ritonavir-boosted darunavir combined with raltegravir or tenofovir-emtricitabine in antiretroviral-naïve adults infected with HIV-1: 96 week results from the NEAT001/ANRS143 randomised non-

inferiority trial. *Lancet*. 2014;384(9958):1942-1951. Available at <http://www.ncbi.nlm.nih.gov/pubmed/25103176>.

90. Taiwo B, Zheng L, Gallien S, et al. Efficacy of a nucleoside-sparing regimen of darunavir/ritonavir plus raltegravir in treatment-naïve HIV-1-infected patients (ACTG A5262). *AIDS*. 2011;25(17):2113-2122. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21857490>.
91. Bedimo RJ, Drechsler H, Jain M, et al. The RADAR study: week 48 safety and efficacy of RAltegravir combined with boosted DARunavir compared to tenofovir/emtricitabine combined with boosted darunavir in antiretroviral-naïve patients. Impact on bone health. *PLoS One*. 2014;9(8):e106221. Available at <http://www.ncbi.nlm.nih.gov/pubmed/25170938>.

## What Not to Use (Last updated March 27, 2012; last reviewed March 27, 2012)

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Some antiretroviral (ARV) regimens or components are not generally recommended because of suboptimal antiviral potency, unacceptable toxicities, or pharmacologic concerns. These are summarized below.

### Antiretroviral Regimens Not Recommended

**Monotherapy with nucleoside reverse transcriptase inhibitor (NRTI).** Single-NRTI therapy does not demonstrate potent and sustained antiviral activity and **should not be used (AII)**. For prevention of mother-to-child transmission (PMTCT), zidovudine (ZDV) monotherapy is not recommended but might be considered in certain unusual circumstances in women with HIV RNA <1,000 copies/mL, although the use of a potent combination regimen is preferred. (See [Perinatal Guidelines](#),<sup>1</sup> available at <http://aidsinfo.nih.gov>.)

Single-drug treatment regimens with a ritonavir (RTV)-boosted protease inhibitor (PI), either lopinavir (LPV),<sup>2</sup> atazanavir (ATV),<sup>3</sup> or darunavir (DRV)<sup>4-5</sup> are under investigation with mixed results, and **cannot be recommended** outside of a clinical trial at this time.

**Dual-NRTI regimens.** These regimens **are not recommended** because they have not demonstrated potent and sustained antiviral activity compared with triple-drug combination regimens **(AI)**.<sup>6</sup>

**Triple-NRTI regimens.** In general, triple-NRTI regimens other than abacavir/lamivudine/zidovudine (ABC/3TC/ZDV) **(BI)** and possibly lamivudine/zidovudine + tenofovir (3TC/ZDV + TDF) **(BII)** **should not be used** because of suboptimal virologic activity<sup>7-9</sup> or lack of data **(AI)**.

### Antiretroviral Components Not Recommended

**Atazanavir (ATV) + indinavir (IDV).** Both of these PIs can cause Grade 3 to 4 hyperbilirubinemia and jaundice. Additive adverse effects may be possible when these agents are used concomitantly. Therefore, these two PIs **are not recommended** for combined use **(AIII)**.

**Didanosine (ddI) + stavudine (d4T).** The combined use of ddI and d4T as a dual-NRTI backbone can result in a high incidence of toxicities, particularly peripheral neuropathy, pancreatitis, and lactic acidosis.<sup>10-13</sup> This combination has been implicated in the deaths of several HIV-infected pregnant women secondary to severe lactic acidosis with or without hepatic steatosis and pancreatitis.<sup>14</sup> Therefore, the combined use of ddI and d4T **is not recommended (AII)**.

**Didanosine (ddI) + tenofovir (TDF).** Use of ddI + TDF may increase ddI concentrations<sup>15</sup> and serious ddI-associated toxicities including pancreatitis and lactic acidosis.<sup>16-17</sup> These toxicities may be lessened by ddI dose reduction. The use of this combination has also been associated with immunologic nonresponse or CD4 cell decline despite viral suppression,<sup>18-19</sup> high rates of early virologic failure,<sup>20-21</sup> and rapid selection of resistance mutations.<sup>20-22</sup> Because of these adverse outcomes, this dual-NRTI combination **is not generally recommended (AII)**. Clinicians caring for patients who are clinically stable on regimens containing ddI + TDF should consider altering the NRTIs to avoid this combination.

**Two-non-nucleoside reverse transcriptase inhibitor (2-NNRTI) combinations.** In the 2NN trial, ARV-naïve participants were randomized to receive once- or twice-daily nevirapine (NVP) versus efavirenz (EFV) versus EFV plus NVP, all combined with d4T and 3TC.<sup>23</sup> A higher frequency of clinical adverse events that led to treatment discontinuation was reported in participants randomized to the two-NNRTI arm. Both EFV and NVP may induce metabolism of etravirine (ETR), which leads to reduction in ETR drug exposure.<sup>24</sup> Based on these findings, the Panel **does not recommend using two NNRTIs in combination in any regimen (AI)**.

**Efavirenz (EFV) in first trimester of pregnancy and in women with significant childbearing potential.**

EFV use was associated with significant teratogenic effects in nonhuman primates at drug exposures similar to those representing human exposure. Several cases of congenital anomalies have been reported after early human gestational exposure to EFV.<sup>25-26</sup> EFV **should be avoided** in pregnancy, particularly during the first trimester, and in women of childbearing potential who are trying to conceive or who are not using effective and consistent contraception (**AIII**). If no other ARV options are available for the woman who is pregnant or at risk of becoming pregnant, the provider should consult with a clinician who has expertise in both HIV infection and pregnancy. (See [Perinatal Guidelines](#),<sup>1</sup> available at <http://aidsinfo.nih.gov>.)

**Emtricitabine (FTC) + lamivudine (3TC).** Both of these drugs have similar resistance profiles and have minimal additive antiviral activity. Inhibition of intracellular phosphorylation may occur *in vivo*, as seen with other dual-cytidine analog combinations.<sup>27</sup> These two agents **should not be used** as a dual-NRTI combination (**AIII**).

**Etravirine (ETR) + unboosted PI.** ETR may induce the metabolism and significantly reduce the drug exposure of unboosted PIs. Appropriate doses of the PIs have not been established<sup>24</sup> (**AII**).

**Etravirine (ETR) + ritonavir (RTV)-boosted atazanavir (ATV) or fosamprenavir (FPV).** ETR may alter the concentrations of these PIs. Appropriate doses of the PIs have not been established<sup>24</sup> (**AII**).

**Etravirine (ETR) + ritonavir (RTV)-boosted tipranavir (TPV).** RTV-boosted TPV significantly reduces ETR concentrations. These drugs **should not be coadministered**<sup>24</sup> (**AII**).

**Nevirapine (NVP) initiated in ARV-naïve women with CD4 counts >250 cells/mm<sup>3</sup> or in ARV-naïve men with CD4 counts >400 cells/mm<sup>3</sup>.** Greater risk of symptomatic hepatic events, including serious and life-threatening events, has been observed in these patient groups. NVP **should not be initiated** in these patients (**BI**) unless the benefit clearly outweighs the risk.<sup>28-30</sup> Patients who experience CD4 count increases to levels above these thresholds as a result of antiretroviral therapy (ART) can be safely switched to NVP.<sup>31</sup>

**Unboosted darunavir (DRV), saquinavir (SQV), or tipranavir (TPV).** The virologic benefit of these PIs has been demonstrated only when they were used with concomitant RTV. Therefore, use of these agents as part of a combination regimen **without RTV is not recommended** (**AII**).

**Stavudine (d4T) + zidovudine (ZDV).** These two NRTIs **should not be used** in combination because of antagonism demonstrated *in vitro*<sup>32</sup> and *in vivo*<sup>33</sup> (**AII**).

**Table 10. Antiretroviral Regimens or Components That Should Not Be Offered At Any Time (page 1 of 2)**

	Rationale	Exception
<b>Antiretroviral Regimens <u>Not</u> Recommended</b>		
<b>Monotherapy with NRTI (AII)</b>	<ul style="list-style-type: none"> <li>• Rapid development of resistance</li> <li>• Inferior ARV activity when compared with combination of three or more ARV agents</li> </ul>	• No exception
<b>Dual-NRTI regimens (AI)</b>	<ul style="list-style-type: none"> <li>• Rapid development of resistance</li> <li>• Inferior ARV activity when compared with combination of three or more ARV agents</li> </ul>	• No exception
<b>Triple-NRTI regimens (AI) except for ABC/ZDV/3TC (BI) or possibly TDF + ZDV/3TC (BII)</b>	<ul style="list-style-type: none"> <li>• High rate of early virologic nonresponse seen when triple-NRTI combinations, including ABC/TDF/3TC and TDF/ddI/3TC, were used as initial regimen in ART-naïve patients.</li> <li>• Other triple-NRTI regimens have not been evaluated.</li> </ul>	• ABC/ZDV/3TC (BI) and possibly TDF + ZDV/3TC (BII) in patients in whom other combinations are not desirable
<b>Antiretroviral Components <u>Not</u> Recommended as Part of an Antiretroviral Regimen</b>		
<b>ATV + IDV (AIII)</b>	<ul style="list-style-type: none"> <li>• Potential additive hyperbilirubinemia</li> </ul>	• No exception
<b>ddI + d4T (AII)</b>	<ul style="list-style-type: none"> <li>• High incidence of toxicities: peripheral neuropathy, pancreatitis, and hyperlactatemia</li> <li>• Reports of serious, even fatal, cases of lactic acidosis with hepatic steatosis with or without pancreatitis in pregnant women</li> </ul>	• No exception
<b>ddI + TDF (AII)</b>	<ul style="list-style-type: none"> <li>• Increased ddI concentrations and serious ddI-associated toxicities</li> <li>• Potential for immunologic nonresponse and/or CD4 cell count decline</li> <li>• High rate of early virologic failure</li> <li>• Rapid selection of resistance mutations at failure</li> </ul>	• Clinicians caring for patients who are clinically stable on regimens containing TDF + ddI should consider altering the NRTIs to avoid this combination.
<b>2-NNRTI combination (AI)</b>	<ul style="list-style-type: none"> <li>• When EFV combined with NVP, higher incidence of clinical adverse events seen when compared with either EFV- or NVP-based regimen.</li> <li>• Both EFV and NVP may induce metabolism and may lead to reductions in ETR exposure; thus, they should not be used in combination with ETR.</li> </ul>	• No exception
<b>EFV in first trimester of pregnancy or in women with significant childbearing potential (AIII)</b>	<ul style="list-style-type: none"> <li>• Teratogenic in nonhuman primates</li> </ul>	• When no other ARV options are available and potential benefits outweigh the risks (BIII)
<b>FTC + 3TC (AIII)</b>	<ul style="list-style-type: none"> <li>• Similar resistance profiles</li> <li>• No potential benefit</li> </ul>	• No exception
<b>ETR + unboosted PI (AII)</b>	<ul style="list-style-type: none"> <li>• ETR may induce metabolism of these PIs; appropriate doses not yet established</li> </ul>	• No exception
<b>ETR + RTV-boosted ATV or FPV (AII)</b>	<ul style="list-style-type: none"> <li>• ETR may alter the concentrations of these PIs; appropriate doses not yet established</li> </ul>	• No exception
<b>ETR + RTV-boosted TPV (AII)</b>	<ul style="list-style-type: none"> <li>• ETR concentration may be significantly reduced by RTV-boosted TPV</li> </ul>	• No exception



**Table 10. Antiretroviral Regimens or Components That Should Not Be Offered At Any Time (page 2 of 2)**

	Rationale	Exception
<b>NVP in ARV-naïve women with CD4 count &gt;250 cells/mm<sup>3</sup> or men with CD4 count &gt;400 cells/mm<sup>3</sup> (BI)</b>	• High incidence of symptomatic hepatotoxicity	• If no other ARV option available; if used, patient should be closely monitored
<b>d4T + ZDV (All)</b>	• Antagonistic effect on HIV-1	• No exception
<b>Unboosted DRV, SQV, or TPV (All)</b>	• Inadequate bioavailability	• No exception

**Acronyms:** 3TC = lamivudine, ABC = abacavir, ATV = atazanavir, d4T = stavudine, ddI = didanosine, DRV = darunavir, EFV = efavirenz, ETR = etravirine, FPV = fosamprenavir, FTC = emtricitabine, IDV = indinavir, NVP = nevirapine, RTV = ritonavir, SQV = saquinavir, TDF = tenofovir, TPV = tipranavir, ZDV = zidovudine

## References

1. Panel on Treatment of HIV-Infected Pregnant Women and Prevention of Perinatal Transmission. Recommendations for use of antiretroviral drugs in pregnant HIV-1-infected women for maternal health and interventions to reduce perinatal HIV transmission in the United States. Available at <http://aidsinfo.nih.gov/contentfiles/lvguidelines/PerinatalGL.pdf>.
2. Delfraissy JF, Flandre P, Delaugerre C, et al. Lopinavir/ritonavir monotherapy or plus zidovudine and lamivudine in antiretroviral-naïve HIV-infected patients. *AIDS*. 2008;22(3):385-393.
3. Swindells S, DiRienzo AG, Wilkin T, et al. Regimen simplification to atazanavir-ritonavir alone as maintenance antiretroviral therapy after sustained virologic suppression. *JAMA*. 2006;296(7):806-814.
4. Arribas JR, Horban A, Gerstoft J, et al. The MONET trial: darunavir/ritonavir with or without nucleoside analogues, for patients with HIV RNA below 50 copies/ml. *AIDS*. 2010;24(2):223-230.
5. Katlama C, Valantin MA, Algarte-Genin M, et al. Efficacy of darunavir/ritonavir maintenance monotherapy in patients with HIV-1 viral suppression: a randomized open-label, noninferiority trial, MONOI-ANRS 136. *AIDS*. 2010;24(15):2365-2374.
6. Hirsch M, Steigbigel R, Staszewski S, et al. A randomized, controlled trial of indinavir, zidovudine, and lamivudine in adults with advanced human immunodeficiency virus type 1 infection and prior antiretroviral therapy. *J Infect Dis*. 1999;180(3):659-665.
7. Gallant JE, Rodriguez AE, Weinberg WG, et al. Early virologic nonresponse to tenofovir, abacavir, and lamivudine in HIV-infected antiretroviral-naïve subjects. *J Infect Dis*. 2005;192(11):1921-1930.
8. Bartlett JA, Johnson J, Herrera G, et al. Long-term results of initial therapy with abacavir and lamivudine combined with efavirenz, amprenavir/ritonavir, or stavudine. *J Acquir Immune Defic Syndr*. 2006;43(3):284-292.
9. Barnas D, Koontz D, Bazmi H, et al. Clonal resistance analyses of HIV type-1 after failure of therapy with didanosine, lamivudine and tenofovir. *Antivir Ther*. 2010;15(3):437-441.
10. Moore RD, Wong WM, Keruly JC, et al. Incidence of neuropathy in HIV-infected patients on monotherapy versus those on combination therapy with didanosine, stavudine and hydroxyurea. *AIDS*. 2000;14(3):273-278.
11. Robbins GK, De Gruttola V, Shafer RW, et al. Comparison of sequential three-drug regimens as initial therapy for HIV-1 infection. *N Engl J Med*. 2003;349(24):2293-2303.
12. Boubaker K, Flepp M, Sudre P, et al. Hyperlactatemia and antiretroviral therapy: the Swiss HIV Cohort Study. *Clin Infect Dis*. 2001;33(11):1931-1937.
13. Coughlan ME, Sommadossi JP, Jhala NC, et al. Symptomatic lactic acidosis in hospitalized antiretroviral-treated patients with human immunodeficiency virus infection: a report of 12 cases. *Clin Infect Dis*. 2001;33(11):1914-1921.
14. FDA FaDA. Caution issued for HIV combination therapy with Zerit and Videx in pregnant women. *HIV Clin*. 2001;13(2):6.

15. Kearney BP, Sayre JR, Flaherty JF, et al. Drug-drug and drug-food interactions between tenofovir disoproxil fumarate and didanosine. *J Clin Pharmacol*. 2005;45(12):1360-1367.
16. Murphy MD, O'Hearn M, Chou S. Fatal lactic acidosis and acute renal failure after addition of tenofovir to an antiretroviral regimen containing didanosine. *Clin Infect Dis*. 2003;36(8):1082-1085.
17. Martinez E, Milinkovic A, de Lazzari E, et al. Pancreatic toxic effects associated with coadministration of didanosine and tenofovir in HIV-infected adults. *Lancet*. 2004;364(9428):65-67.
18. Barrios A, Rendon A, Negredo E, et al. Paradoxical CD4+ T-cell decline in HIV-infected patients with complete virus suppression taking tenofovir and didanosine. *AIDS*. 2005;19(6):569-575.
19. Negredo E, Bonjoch A, Paredes R, et al. Compromised immunologic recovery in treatment-experienced patients with HIV infection receiving both tenofovir disoproxil fumarate and didanosine in the TORO studies. *Clin Infect Dis*. 2005;41(6):901-905.
20. Leon A, Martinez E, Mallolas J, et al. Early virological failure in treatment-naïve HIV-infected adults receiving didanosine and tenofovir plus efavirenz or nevirapine. *AIDS*. 2005;19(2):213-215.
21. Maitland D, Moyle G, Hand J, et al. Early virologic failure in HIV-1 infected subjects on didanosine/tenofovir/efavirenz: 12-week results from a randomized trial. *AIDS*. 2005;19(11):1183-1188.
22. Podzamczar D, Ferrer E, Gatell JM, et al. Early virological failure with a combination of tenofovir, didanosine and efavirenz. *Antivir Ther*. 2005;10(1):171-177.
23. van Leth F, Phanuphak P, Ruxrungtham K, et al. Comparison of first-line antiretroviral therapy with regimens including nevirapine, efavirenz, or both drugs, plus stavudine and lamivudine: a randomised open-label trial, the 2NN Study. *Lancet*. 2004;363(9417):1253-1263.
24. Tibotec, Inc. Intelence (package insert) 2009.
25. Fundaro C, Genovese O, Rendeli C, et al. Myelomeningocele in a child with intrauterine exposure to efavirenz. *AIDS*. 2002;16(2):299-300.
26. Antiretroviral Pregnancy Registry Steering Committee. Antiretroviral Pregnancy Registry international interim report for 1 Jan 1989 - 31 January 2007. 2007; <http://www.APREgistry.com>.
27. Bethell R, Adams J, DeMuys J, et al. Pharmacological evaluation of a dual deoxycytidine analogue combination: 3TC and SPD754. Paper presented at: 11th Conference on Retroviruses and Opportunistic Infections; February 8-11, 2004; San Francisco, California. Abstract 138.
28. Baylor MS, Johann-Liang R. Hepatotoxicity associated with nevirapine use. *J Acquir Immune Defic Syndr*. 2004;35(5):538-539.
29. Sanne I, Mommeja-Marin H, Hinkle J, et al. Severe hepatotoxicity associated with nevirapine use in HIV-infected subjects. *J Infect Dis*. 2005;191(6):825-829.
30. Boehringer Ingelheim. Dear Health Care Professional Letter. *Clarification of risk factors for severe, life-threatening and fatal hepatotoxicity with VIRAMUNE® (nevirapine)* 2004.
31. Kesselring AM, Wit FW, Sabin CA, et al. Risk factors for treatment-limiting toxicities in patients starting nevirapine-containing antiretroviral therapy. *AIDS*. 2009;23(13):1689-1699.
32. Hoggard PG, Kewn S, Barry MG, et al. Effects of drugs on 2',3'-dideoxy-2',3'-didehydrothymidine phosphorylation *in vitro*. *Antimicrob Agents Chemother*. 1997;41(6):1231-1236.
33. Havlir DV, Tierney C, Friedland GH, et al. *In vivo* antagonism with zidovudine plus stavudine combination therapy. *J Infect Dis*. 2000;182(1):321-325.

# Management of the Treatment-Experienced Patient

## Virologic Failure (Last updated April 8, 2015; last reviewed April 8, 2015)

Panel's Recommendations
<ul style="list-style-type: none"><li>Assessing and managing a patient experiencing failure of antiretroviral therapy (ART) is complex. Expert advice is critical and should be sought.</li><li>Evaluation of virologic failure should include an assessment of adherence, drug-drug or drug-food interactions, drug tolerability, HIV RNA and CD4 T lymphocyte (CD4) cell count trends over time, treatment history, and prior and current drug-resistance testing results.</li><li>Drug-resistance testing should be performed while the patient is taking the failing antiretroviral (ARV) regimen <b>(AI)</b> or within 4 weeks of treatment discontinuation <b>(AII)</b>. Even if more than 4 weeks have elapsed since ARVs were discontinued, resistance testing—although it may not detect previously selected resistance mutations—can still provide useful information to guide therapy <b>(CIII)</b>.</li><li>The goal of treatment for ART-experienced patients with drug resistance who are experiencing virologic failure is to establish virologic suppression (i.e., HIV RNA below the lower limits of detection of currently used assays) <b>(AI)</b>.</li><li>A new regimen should include at least two, and preferably three, fully active agents <b>(AI)</b>. A fully active agent is one that is expected to have uncompromised activity on the basis of the patient's treatment history and drug-resistance testing results and/or the drug's novel mechanism of action.</li><li>In general, adding a single ARV agent to a virologically failing regimen is <b>not</b> recommended because this may risk the development of resistance to all drugs in the regimen <b>(BII)</b>.</li><li>For some highly ART-experienced patients, maximal virologic suppression is not possible. In this case, ART should be continued <b>(AI)</b> with regimens designed to minimize toxicity, preserve CD4 cell counts, and delay clinical progression.</li><li>When it is not possible to construct a viable suppressive regimen for a patient with multidrug resistant HIV, the clinician should consider enrolling the patient in a clinical trial of investigational agents or contacting pharmaceutical companies that may have investigational agents available.</li><li>Discontinuing or briefly interrupting therapy may lead to a rapid increase in HIV RNA and a decrease in CD4 cell count and increases the risk of clinical progression. Therefore, this strategy is <b>not</b> recommended in the setting of virologic failure <b>(AI)</b>.</li></ul>
<b>Rating of Recommendations:</b> A = Strong; B = Moderate; C = Optional
<b>Rating of Evidence:</b> I = Data from randomized controlled trials; II = Data from well-designed nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion

Antiretroviral (ARV) regimens currently recommended for initial therapy of HIV-infected patients have a high likelihood of achieving and maintaining plasma HIV RNA levels below the lower limits of detection (LLOD) of currently used assays (see [What to Start](#)). Patients on antiretroviral therapy (ART) who do not achieve this treatment goal or who experience virologic rebound often develop resistance mutations to one or more components of their regimen. Based on surveillance data for HIV patients in care in selected cities in the United States in 2009, an estimated 89% of the patients were receiving ART, of whom 72% had viral loads <200 copies/mL.<sup>1</sup> Many patients with detectable viral loads are non-adherent to treatment. Depending on their treatment histories, some of these patients may have minimal or no drug resistance; others may have extensive resistance. Managing patients with extensive resistance is complex and usually requires consultation with an HIV expert. This section of the guidelines defines virologic failure in patients on ART and discusses strategies to manage these individuals.

### Virologic Response Definitions

The following definitions are used in this section to describe the different levels of virologic response to ART.

**Virologic suppression:** A confirmed HIV RNA level below the LLOD of available assays

**Virologic failure:** The inability to achieve or maintain suppression of viral replication to an HIV RNA level <200 copies/mL

**Incomplete virologic response:** Two consecutive plasma HIV RNA levels  $\geq 200$  copies/mL after 24 weeks on an ARV regimen in a patient who has not yet had documented virologic suppression on this regimen. A patient's baseline HIV RNA level may affect the time course of response, and some regimens will take longer than others to suppress HIV RNA levels.

**Virologic rebound:** Confirmed HIV RNA  $\geq 200$  copies/mL after virologic suppression

**Virologic blip:** After virologic suppression, an isolated detectable HIV RNA level that is followed by a return to virologic suppression

## ***ART Treatment Goals and Virologic Responses***

The goal of ART is to suppress HIV replication to a level below which drug-resistance mutations do not emerge. Although not conclusive, the evidence suggests that selection of drug-resistance mutations does not occur in patients with HIV RNA levels persistently suppressed to below the LLOD of current assays.<sup>2</sup>

Viremia “blips”—defined by viral suppression followed by an isolated detectable HIV RNA level and subsequent return to undetectable levels—are not usually associated with subsequent virologic failure.<sup>3</sup> In contrast, there is controversy regarding the clinical implications of persistent HIV RNA levels between the LLOD and <200 copies/mL in patients on ART. Furthermore, viremia at this threshold is detected with some frequency by commonly used real-time polymerase chain reaction (PCR) assays, which are more sensitive than PCR-based viral load platforms used in the past.<sup>4-6</sup> Findings from a large retrospective analysis showed that, as a threshold for virologic failure, HIV RNA levels of 200 copies/mL and <50 copies/mL had the same predictive value for subsequent rebound to >200 copies/mL.<sup>7</sup> Two other retrospective studies also support the supposition that virologic rebound is more likely to occur in patients with viral loads >200 copies/mL than in those with low-level viremia between 50 to 199 copies/mL.<sup>8,9</sup> However, other studies have suggested that viremia at this low level (<200 copies/mL) can be predictive of progressive viral rebound<sup>10,11</sup> and can be associated with the evolution of drug resistance.<sup>12</sup>

Persistent HIV RNA levels  $\geq 200$  copies/mL are often associated with evidence of viral evolution and accumulation of drug-resistance mutations.<sup>13</sup> This association is particularly common when HIV RNA levels are >500 copies/mL.<sup>14</sup> Therefore, persistent plasma HIV RNA levels  $\geq 200$  copies/mL should be considered virologic failure.

## ***Causes of Virologic Failure***

Virologic failure can occur for many reasons. Data from patient cohorts in the earlier era of combination ART suggested that suboptimal adherence and drug intolerance/toxicity accounted for 28% to 40% of virologic failure and regimen discontinuations.<sup>15,16</sup> Presence of pre-existing (transmitted) drug resistance may also be the cause of virologic failure.<sup>17</sup> Virologic failure may be associated with both patient- and regimen-related factors, as listed below:

- **Patient-Related Factors**
  - Higher pretreatment or baseline HIV RNA level (depending on the specific regimen used)
  - Lower pretreatment or nadir CD4 T lymphocyte (CD4) cell count (depending on the specific regimen used)
  - Comorbidities that may affect adherence (e.g., active substance abuse, psychiatric disease, neurocognitive deficits)
  - Presence of drug-resistant virus, either transmitted or acquired

- Prior treatment failure
- Incomplete medication adherence and missed clinic appointments
- Interruption of or intermittent access to ART
- **ARV Regimen-Related Factors**
  - Drug adverse effects
  - Suboptimal pharmacokinetics (variable absorption, metabolism, or possibly penetration into reservoirs)
  - Suboptimal virologic potency
  - Reduced efficacy because of a patient's prior exposure to suboptimal regimens (e.g., functional monotherapy)
  - Food requirements
  - High pill burden and/or dosing frequency
  - Adverse drug-drug interactions with concomitant medications
  - Prescription errors
  - Cost and affordability of ARVs (i.e., may affect a patient's ability to access or continue therapy)

## ***Management of Patients with Virologic Failure***

### **Assessment of Virologic Failure**

If virologic failure is suspected or confirmed, a thorough assessment that includes consideration of the factors listed in the Causes of Virologic Failure section above is indicated. Often the causes of virologic failure can be identified, but in some cases, the causes are not obvious. It is important to distinguish among the causes of virologic failure because the approaches to subsequent therapy differ. The following potential causes of virologic failure should be explored in depth:

- **Suboptimal Adherence.** Assess the patient's adherence to the regimen. Identify and address the underlying cause(s) for incomplete adherence (e.g., drug intolerance, difficulty accessing medications, depression, active substance abuse) and, if possible, simplify the regimen (e.g., decrease pill count or dosing frequency). (See [Adherence](#).)
- **Medication Intolerance.** Assess the patient's tolerance of the current regimen and the severity and duration of side effects, keeping in mind that even minor side effects can affect adherence. Management strategies to address intolerance in the absence of drug resistance may include:
  - Symptomatic treatment (e.g., antiemetics, antidiarrheals)
  - A switch from one ARV in a regimen to another agent in the same drug class (see the [Adverse Effects](#) section)
  - A switch from one drug class to another class (e.g., from a non-nucleoside reverse transcriptase inhibitor [NNRTI] to a protease inhibitor [PI] or an integrase strand transfer inhibitor [INSTI]), if necessary (see the [Adverse Effects](#) section)
- **Pharmacokinetic Issues**
  - Review food requirement for each medication, and assess whether the patient adheres to the requirement.
  - Review the patient's recent history of gastrointestinal symptoms such as vomiting or diarrhea that may result in short-term malabsorption.
  - Review concomitant medications and dietary supplements for possible adverse drug-drug interactions (consult the [Drug Interactions](#) section and tables for common interactions) and, if possible, make appropriate substitutions for ARV agents and/or concomitant medications.
  - Consider therapeutic drug monitoring if pharmacokinetic drug-drug interactions or impaired drug absorption leading to decreased ARV exposure is suspected (see also [Exposure-Response](#))



### Relationship and Therapeutic Drug Monitoring).

- **Suspected Drug Resistance.** Perform resistance testing while the patient is still taking the failing regimen or within 4 weeks of regimen discontinuation if the patient's plasma HIV RNA level is >1,000 copies/mL (**AI**), and possibly even if between 500 to 1,000 copies/mL (**BII**). (See [Drug-Resistance Testing](#).) In some patients, resistance testing should be considered even after treatment interruptions of more than 4 weeks, recognizing that the lack of evidence of resistance in this setting does not exclude the possibility that resistance mutations may be present at low levels (**CIII**). Evaluate the extent of drug resistance, taking into account the patient's past treatment history and prior resistance-test results. Drug resistance is cumulative; thus, all prior treatment history and resistance test results should be considered when evaluating resistance. Genotypic or phenotypic testing provides information relevant for selecting nucleoside reverse transcriptase inhibitors (NRTIs), NNRTIs, PIs, and INSTIs. Additional drug-resistance tests for patients experiencing failure on a fusion inhibitor (**AII**) and viral tropism tests for patients experiencing failure on a CCR5 antagonist (**BIII**) are also available. (See [Drug-Resistance Testing](#).)

### **Approach to Patients with Confirmed Virologic Failure**

Once virologic failure is confirmed, every effort should be made to assess whether suboptimal adherence and drug-drug or drug-food interactions may be contributing to the inadequate virologic response to ART. If virologic failure persists after these issues have been adequately addressed, resistance testing should be performed, and the regimen should be changed as soon as possible to avoid progressive accumulation of resistance mutations.<sup>18</sup> In addition, several studies have shown that virologic responses to new regimens are greater in individuals with lower HIV RNA levels<sup>10,19</sup> and/or higher CD4 cell counts at the time of regimen changes.<sup>10,19</sup> Discontinuing or briefly interrupting therapy in a patient with viremia may lead to a rapid increase in HIV RNA and a decrease in CD4 cell count and increases the risk of clinical progression;<sup>20,21</sup> therefore, this strategy is **not** recommended (**AI**). See [Discontinuation or Interruption of Antiretroviral Therapy](#).

Ideally, a new ARV regimen should contain at least two, and preferably three, fully active drugs whose predicted activity is based on the patient's drug treatment history, resistance testing, or the mechanistic action of a new drug class (**AI**).<sup>10,22-31</sup> Despite drug resistance, some ARV drugs (e.g., NRTIs) may contribute partial ARV activity to a regimen,<sup>21</sup> while other agents (e.g., enfuvirtide [T20], NNRTIs, the INSTI raltegravir [RAL]) likely will not.<sup>32-34</sup> Using a "new" drug that a patient has never used previously does not ensure that the drug will be fully active; there is potential for cross-resistance, particularly among drugs from the same class. In addition, archived drug-resistance mutations may not be detected by standard drug-resistance tests, particularly if testing is performed when the patient is not taking the drug in question. Therefore, both treatment history and prior and current drug-resistance test results must be considered when designing a new regimen. When designing a new ART regimen, drug potency and viral susceptibility are more important factors to consider than the number of component drugs.

In general, patients who receive at least three active drugs, selected based on a review of the patient's treatment history and past and most current drug-resistance test results, experience better and more sustained virologic response than those receiving fewer active drugs in the regimen.<sup>23,24,26,27,35,36</sup> However, there are increasing data in treatment-naïve and treatment-experienced patients showing that an active pharmacokinetically enhanced PI plus one other active drug or several partially active drugs will effectively reduce viral load in most patients.<sup>37-40</sup> Active drugs are ARVs that, based on resistance test results and treatment history, are expected to have antiviral activity equivalent to that seen when there is no resistance to the specific drugs; ARVs with partial activity are those predicted to reduce HIV RNA but to a lesser extent than when there is no underlying drug resistance. The activity of a given drug must be uniquely defined for each patient. Active drugs may be newer members of existing drug classes that are active against HIV isolates that are resistant to older drugs in the same classes (e.g., efavirenz [ETR], darunavir [DRV] and tipranavir, and dolutegravir [DTG]) An active drug may also be one with unique mechanisms of action (e.g.,



the fusion inhibitor T20, the CCR5 antagonist maraviroc in patients with no detectable CXCR4-using virus). In the presence of certain drug resistance mutations, some ARVs such as DTG, ritonavir-boosted DRV, and ritonavir-boosted lopinavir (LPV/r) need to be given twice daily instead of once daily to achieve higher drug concentrations necessary to be active against the less sensitive virus.<sup>41,42</sup>

### Addressing Detectable Viral Load in Different Clinical Situations

- **HIV RNA above the LLOD and <200 copies/mL.** Confirm that levels remain above the LLOD and assess adherence, drug-drug interactions (including those with over-the-counter products and supplements), and drug-food interactions. Patients with HIV RNA typically below the LLOD with transient increases in HIV RNA (i.e., blips) do not require a change in treatment (**AII**).<sup>5</sup> Although there is no consensus on how to manage patients with persistent HIV RNA levels above the LLOD and <200 copies/mL, the risk of emerging resistance is believed to be relatively low. Therefore, these patients should maintain on their current regimens and have HIV RNA levels monitored at least every 3 months to assess the need for changes in ART in the future (**AIII**).
- **HIV RNA  $\geq$ 200 and <1,000 copies/mL.** Confirm that HIV RNA levels remain in this range and assess adherence and potential drug-drug interactions (including those with over-the-counter products and supplements) and drug-food interactions. In contrast to patients with HIV RNA levels persistently <200 copies/mL, those with levels persistently  $\geq$ 200 copies/mL often develop drug resistance, particularly with HIV RNA levels >500 copies/mL.<sup>8,9</sup> Persistent plasma HIV RNA levels in the 200 to 1,000 copies/mL range should be considered as virologic failure, and resistance testing should be attempted, particularly if HIV RNA >500 copies/mL. When resistance testing can successfully be performed and no resistance is detected, manage the patient as outlined below in the section on **HIV RNA >1,000 copies/mL and no drug resistance identified**. If drug resistance is detected, manage the patient as outlined below in the section on **HIV RNA >1,000 copies/mL and drug resistance identified**. When resistance testing cannot be performed because of low-level viremia, the decision whether to empirically change ARVs should be made on a case-by-case basis.
- **HIV RNA >1,000 copies/mL and no drug resistance identified.** This scenario is almost always associated with suboptimal adherence. Conduct a thorough assessment to determine the level of adherence and identify any drug-drug and drug-food interactions. Consider the timing of the drug-resistance test (e.g., was the patient mostly or completely ART-non-adherent for more than 4 weeks before testing). If the current regimen is well tolerated and there are no significant drug-drug or drug-food interactions, it is reasonable to resume the same regimen. If the agents are poorly tolerated or there are important drug-drug or drug-food interactions, consider changing the regimen. Two to four weeks after treatment is resumed or started, repeat viral load testing; if viral load remains >500 copies/mL, perform genotypic testing to determine whether a resistant viral strain emerges (**CIII**).
- **HIV RNA >1,000 copies/mL and drug resistance identified.** The availability of newer ARVs, including some with new mechanisms of action, makes it possible to suppress HIV RNA levels to below the LLOD in most of these patients. The options in this setting depend on the extent of drug resistance present and are addressed in the clinical scenarios outlined below.

### Management of Virologic Failure in Different Clinical Scenarios

#### First Regimen Failure

- **Failing an NNRTI plus NRTI regimen.** Patients failing an NNRTI-based regimen often have viral resistance to the NNRTI, with or without lamivudine (3TC) and emtricitabine (FTC) resistance. Although several options are available for these patients, several studies have explored the activity of a pharmacokinetically boosted PI with NRTIs or an INSTI.<sup>43-45</sup> Two of the studies found that regimens containing a ritonavir-boosted PI (PI/r) combined with NRTIs were as active as regimens containing the PI/r

combined with RAL.<sup>43,45</sup> Two studies also demonstrated higher rates of virologic suppression with use of a PI/r plus NRTIs than with a PI/r alone.<sup>44,45</sup> On the basis of these studies, even patients with NRTI resistance can often be treated with a pharmacokinetically boosted PI plus NRTIs or RAL (AI). Although LPV/r was used in these studies, it is likely that other pharmacokinetically boosted PIs would behave similarly. Although data are limited, the second-generation NNRTI ETR or the other INSTIs (i.e., elvitegravir [EVG] or DTG) combined with a pharmacokinetically boosted PI may also be options in this setting.

- **Failing a pharmacokinetically boosted PI plus NRTI regimen.** In this scenario, most patients will have either no resistance or resistance limited to 3TC and FTC.<sup>46,47</sup> Failure in this setting is often attributed to poor adherence, drug-drug interactions, or drug-food interactions. A systematic review of multiple randomized trials of PI/r first-line failure showed that maintaining the same regimen, presumably with efforts to enhance adherence, is as effective as changing to new regimens with or without drugs from new classes.<sup>48</sup> In this setting, resistance testing should be performed along with an assessment of overall adherence and tolerability of the regimen. If the regimen is well tolerated and there are no concerns regarding drug-drug or drug-food interactions, the regimen can be continued with adherence support and viral monitoring. Alternatively, if poor tolerability or interactions may be contributing to virologic failure, the regimen can be modified to include a different pharmacokinetically boosted PI plus NRTIs—even if not all of the NRTIs are fully active—or to a new non-PI-based regimen that includes more than two fully active agents (**AII**).
- **Failing an INSTI plus NRTI regimen.** Virologic failure with a regimen consisting of RAL plus two NRTIs or with EVG/cobicistat/tenofovir disoproxil fumarate/FTC may be associated with emergent resistance to 3TC and FTC and possibly the INSTI.<sup>49</sup> Viruses with INSTI resistance often have virus still susceptible to DTG.<sup>19</sup> In contrast, persons failing DTG plus two NRTI first-line therapy in clinical trials have not yet been shown to develop phenotypic resistance to DTG.<sup>49</sup> There are no clinical trial data to guide therapy for first-line INSTI failures, although one can likely extrapolate from the data for NNRTI failures. Thus, patients with first-line INSTI failure should respond to a pharmacokinetically boosted PI plus NRTIs (**AII**). A pharmacokinetically boosted PI plus an INSTI may also be a viable option in patients with no INSTI resistance (**BII**). In the setting the virus is found to have resistance to RAL and EVG but remains susceptible to DTG, DTG can be used in combination with a pharmacokinetically boosted PI. If no resistance is identified, the patient should be managed as outlined above in the section on virologic failure without resistance.

## Second-Line Regimen Failure and Beyond

- **Drug resistance with treatment options allowing for full virologic suppression.** Depending on treatment history and drug-resistance data, one can predict whether or not to have a fully active pharmacokinetically boosted PI to include in future regimens. For example, those who have no documented PI resistance and previously have never been treated with an unboosted PI are likely to harbor virus that is fully susceptible to ARVs in the PI class. In this setting, viral suppression should be achievable using a pharmacokinetically boosted PI combined with either NRTIs or an INSTI—provided the virus is susceptible to the INSTI. If a fully susceptible pharmacokinetically boosted PI is not an option, the new regimen should include at least two, and preferably three, fully active agents, if possible. Drugs to be included in the regimen should be selected based on the likelihood that they will be active as determined by the patient's treatment history, past and present drug-resistance testing, and tropism testing if a CCR5 antagonist is being considered.
- **Multidrug resistance without treatment options allowing for full virologic suppression.** Use of currently available ARVs has resulted in a dramatic decline in the number of patients who have few treatment options because of multi-class drug resistance.<sup>50,51</sup> Despite this progress, there remain patients who have experienced toxicities and/or developed resistance to all or most currently available drugs. If maximal virologic suppression cannot be achieved, the goals of ART will be to preserve immunologic

function, prevent clinical progression, and minimize increasing resistance to drug classes that may eventually include new drugs that may be important for future regimens. Consensus on the optimal management of these patients is lacking. If resistance to NNRTIs, T20, EVG or RAL are identified, there is rarely a reason to continue these drugs, as there is little evidence that keeping them in the regimen helps delay disease progression (**BII**). Moreover, continuing these drugs, in particular INSTIs, may allow for further increasing resistance and within-class cross resistance that may limit future treatment options. It should be noted that even partial virologic suppression of HIV RNA to  $>0.5 \log_{10}$  copies/mL from baseline correlates with clinical benefits.<sup>50,52</sup> Cohort studies provide evidence that continuing therapy, even in the presence of viremia and the absence of CD4 count increases, reduces the risk of disease progression.<sup>53</sup> Other cohort studies suggest continued immunologic and clinical benefits with even modest reductions in HIV RNA levels.<sup>54,55</sup> However, all these potential benefits must be balanced with the ongoing risk of accumulating additional resistance mutations. In general, adding a single fully active ARV to the regimen is **not** recommended because of the risk of rapid development of resistance (**BII**).

Patients with ongoing viremia who lack sufficient treatment options to construct a fully suppressive regimen may be candidates for research studies or expanded access programs or may qualify for single-patient access of an investigational new drug as specified in Food and Drug Administration regulations:

<http://www.fda.gov/AboutFDA/CentersOffices/OfficeofMedicalProductsandTobacco/CDER/ucm163982.htm>.

Information about these programs may also be available from the sponsoring pharmaceutical manufacturer.

- **Previously treated patient with suspected drug resistance who need care but present with limited information (i.e., incomplete or no self-reported history, medical records, or resistance-testing results).** Every effort should be made to obtain the patient's medical records and prior drug-resistance testing results; however, this may not always be possible. One strategy is to restart the most recent ARV regimen and assess drug resistance in 2 to 4 weeks to guide selection of the next regimen. Another strategy is to start two or three drugs predicted to be active on the basis of the patient's treatment history.

### ***Isolated Central Nervous System (CNS) Virologic Failure and New Onset Neurologic Symptoms***

Presentation with new-onset CNS signs and symptoms has been reported as a rare form of virologic failure. These patients present with new, usually subacute, neurological symptoms associated with breakthrough of HIV infection within the CNS compartment despite plasma HIV RNA suppression.<sup>56,57</sup> Clinical evaluation frequently shows abnormalities on MRI brain imaging and abnormal cerebrospinal fluid (CSF) findings with characteristic lymphocytic pleocytosis. When available, measurement of CSF HIV RNA shows higher concentrations in the CSF than in plasma, and in most patients, evidence of drug-resistant CSF virus. Drug-resistance testing of HIV in CSF, if available, can be used to guide changes in the treatment regimen according to principles outlined above for plasma HIV RNA resistance (**CII**). In these patients it may be useful to consider CNS pharmacokinetics in drug selection (**CIII**). If CSF HIV resistance testing is not available, the regimen may be changed based on the patient's treatment history or on predicted drug penetration into the CNS<sup>58-60</sup> (**CIII**). This "neurosymptomatic" CNS viral escape should be distinguished from: (1) other CNS infections that can induce a transient increase in CSF HIV RNA (e.g., herpes zoster<sup>61</sup>), (2) incidental detection of asymptomatic mild CSF HIV RNA elevation likely equivalent to plasma blips,<sup>62</sup> or (3) relatively common chronic, usually mild, neurocognitive impairment in HIV-infected patients without evidence of CNS viral breakthrough.<sup>63</sup> None of these latter conditions currently warrant a change in ART.<sup>64</sup>

## **Summary**

In summary, the management of treatment-experienced patients with virologic failure often requires expert advice to construct virologically suppressive regimens. Before modifying a regimen, it is critical to carefully evaluate the cause(s) of virologic failure, including incomplete adherence, poor tolerability, and drug and food interactions, as well as review HIV RNA and CD4 cell count changes over time, treatment history, and

drug-resistance test results. If HIV RNA suppression is not possible with currently approved agents, consider use of investigational agents through participation in clinical trials or expanded/single-patient access programs. If virologic suppression is still not achievable, the choice of regimens should focus on minimizing toxicity and preserving treatment options while maintaining CD4 cell counts to delay clinical progression.

## References

1. Blair JM, Fagan JL, Frazier EL, et al. Behavioral and clinical characteristics of persons receiving medical care for HIV infection - Medical Monitoring Project, United States, 2009. *Morb Mortal Wkly Rep Surveill Summ*. 2014;63 Suppl 5:1-22. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24941443>.
2. Kieffer TL, Finucane MM, Nettles RE, et al. Genotypic analysis of HIV-1 drug resistance at the limit of detection: virus production without evolution in treated adults with undetectable HIV loads. *J Infect Dis*. 2004;189(8):1452-1465. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=15073683](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15073683).
3. Nettles RE, Kieffer TL, Kwon P, et al. Intermittent HIV-1 viremia (Blips) and drug resistance in patients receiving HAART. *JAMA*. 2005;293(7):817-829. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=15713771](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15713771).
4. Lima V, Harrigan R, Montaner JS. Increased reporting of detectable plasma HIV-1 RNA levels at the critical threshold of 50 copies per milliliter with the Taqman assay in comparison to the Amplicor assay. *J Acquir Immune Defic Syndr*. 2009;51(1):3-6. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19247185](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19247185).
5. Gatanaga H, Tsukada K, Honda H, et al. Detection of HIV type 1 load by the Roche Cobas TaqMan assay in patients with viral loads previously undetectable by the Roche Cobas Amplicor Monitor. *Clin Infect Dis*. 2009;48(2):260-262. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19113986](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19113986).
6. Willig JH, Nevin CR, Raper JL, et al. Cost ramifications of increased reporting of detectable plasma HIV-1 RNA levels by the Roche COBAS AmpliPrep/COBAS TaqMan HIV-1 version 1.0 viral load test. *J Acquir Immune Defic Syndr*. 2010;54(4):442-444. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=20611035](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20611035).
7. Ribaud H, Lennox J, Currier J, et al. Virologic failure endpoint definition in clinical trials: Is using HIV-1 RNA threshold <200 copies/mL better than <50 copies/mL? An analysis of ACTG studies. 16th Conference on Retroviruses and Opportunistic Infections. Montreal, Canada, 2009.
8. Antiretroviral Therapy Cohort C. Impact of low-level viremia on clinical and virological outcomes in treated HIV-1-infected patients. *AIDS*. 2015;29(3):373-383. Available at <http://www.ncbi.nlm.nih.gov/pubmed/25686685>.
9. Boillat-Blanco N, Darling KE, Schoni-Affolter F, et al. Virological outcome and management of persistent low-level viraemia in HIV-1-infected patients: 11 years of the Swiss HIV Cohort Study. *Antivir Ther*. 2014. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24964403>.
10. Eron JJ, Cooper DA, Steigbigel RT, et al. Efficacy and safety of raltegravir for treatment of HIV for 5 years in the BENCHMRK studies: final results of two randomised, placebo-controlled trials. *Lancet Infect Dis*. 2013;13(7):587-596. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23664333>.
11. Laprise C, de Pokomandy A, Baril JG, Dufresne S, Trottier H. Virologic failure following persistent low-level viremia in a cohort of HIV-positive patients: results from 12 years of observation. *Clin Infect Dis*. 2013;57(10):1489-1496. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23946221>.
12. Taiwo B, Gallien S, Aga S, et al. HIV drug resistance evolution during persistent near-target viral suppression. *Antiviral Therapy* 2010;15:A38.
13. Aleman S, Soderbarg K, Visco-Comandini U, Sitbon G, Sonnerborg A. Drug resistance at low viraemia in HIV-1-infected patients with antiretroviral combination therapy. *AIDS*. 2002;16(7):1039-1044. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=11953470](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11953470).
14. Karlsson AC, Younger SR, Martin JN, et al. Immunologic and virologic evolution during periods of intermittent and persistent low-level viremia. *AIDS*. 2004;18(7):981-989. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=15096800](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15096800).
15. d'Arminio Monforte A, Lepri AC, Rezza G, et al. Insights into the reasons for discontinuation of the first highly active



antiretroviral therapy (HAART) regimen in a cohort of antiretroviral naive patients. I.CO.N.A. Study Group. Italian Cohort of Antiretroviral-Naive Patients. *AIDS*. 2000;14(5):499-507. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=10780712](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=10780712).

16. Mocroft A, Youle M, Moore A, et al. Reasons for modification and discontinuation of antiretrovirals: results from a single treatment centre. *AIDS*. 2001;15(2):185-194. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=11216926](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11216926).
17. Paredes R, Lalama CM, Ribaud HJ, et al. Pre-existing minority drug-resistant HIV-1 variants, adherence, and risk of antiretroviral treatment failure. *J Infect Dis*. 2010;201(5):662-671. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=20102271](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20102271).
18. Hosseinipour MC, van Oosterhout JJ, Weigel R, et al. The public health approach to identify antiretroviral therapy failure: high-level nucleoside reverse transcriptase inhibitor resistance among Malawians failing first-line antiretroviral therapy. *AIDS*. 2009;23(9):1127-1134. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19417582](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19417582).
19. Castagna A, Maggiolo F, Penco G, et al. Dolutegravir in antiretroviral-experienced patients with raltegravir- and/or elvitegravir-resistant HIV-1: 24-week results of the phase III VIKING-3 study. *J Infect Dis*. 2014. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24446523>.
20. Lawrence J, Mayers DL, Hullsiek KH, et al. Structured treatment interruption in patients with multidrug-resistant human immunodeficiency virus. *N Engl J Med*. 2003;349(9):837-846. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=12944569](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=12944569).
21. Deeks SG, Wrin T, Liegler T, et al. Virologic and immunologic consequences of discontinuing combination antiretroviral-drug therapy in HIV-infected patients with detectable viremia. *N Engl J Med*. 2001;344(7):472-480. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=11172188](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11172188).
22. Cooper DA, Steigbigel RT, Gatell JM, et al. Subgroup and resistance analyses of raltegravir for resistant HIV-1 infection. *N Engl J Med*. 2008;359(4):355-365. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18650513](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18650513).
23. Lazzarin A, Clotet B, Cooper D, et al. Efficacy of enfuvirtide in patients infected with drug-resistant HIV-1 in Europe and Australia. *N Engl J Med*. 2003;348(22):2186-2195. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=12773645](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=12773645).
24. Lalezari JP, Henry K, O'Hearn M, et al. Enfuvirtide, an HIV-1 fusion inhibitor, for drug-resistant HIV infection in North and South America. *N Engl J Med*. 2003;348(22):2175-2185. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=12637625](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=12637625).
25. Reynes J, Arasteh K, Clotet B, et al. TORO: ninety-six-week virologic and immunologic response and safety evaluation of enfuvirtide with an optimized background of antiretrovirals. *AIDS Patient Care STDS*. 2007;21(8):533-543. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17711378](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17711378).
26. Clotet B, Bellos N, Molina JM, et al. Efficacy and safety of darunavir-ritonavir at week 48 in treatment-experienced patients with HIV-1 infection in POWER 1 and 2: a pooled subgroup analysis of data from two randomised trials. *Lancet*. 2007;369(9568):1169-1178. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17416261](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17416261).
27. Steigbigel RT, Cooper DA, Kumar PN, et al. Raltegravir with optimized background therapy for resistant HIV-1 infection. *N Engl J Med*. 2008;359(4):339-354. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18650512](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18650512).
28. Katlama C, Haubrich R, Lalezari J, et al. Efficacy and safety of etravirine in treatment-experienced, HIV-1 patients: pooled 48 week analysis of two randomized, controlled trials. *AIDS*. 2009;23(17):2289-2300. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19710593](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19710593).
29. Gulick RM, Lalezari J, Goodrich J, et al. Maraviroc for previously treated patients with R5 HIV-1 infection. *N Engl J Med*. 2008;359(14):1429-1441. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18832244](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18832244).
30. Fatkenheuer G, Nelson M, Lazzarin A, et al. Subgroup analyses of maraviroc in previously treated R5 HIV-1 infection. *N Engl J Med*. 2008;359(14):1442-1455. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18832245](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18832245).
31. Cahn P, Pozniak AL, Mingrone H, et al. Dolutegravir versus raltegravir in antiretroviral-experienced, integrase-inhibitor-

naive adults with HIV: week 48 results from the randomised, double-blind, non-inferiority SAILING study. *Lancet*. 2013;382(9893):700-708. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23830355>.

32. Deeks SG, Hoh R, Neilands TB, et al. Interruption of treatment with individual therapeutic drug classes in adults with multidrug-resistant HIV-1 infection. *J Infect Dis*. 2005;192(9):1537-1544. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=16206068](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16206068).
33. Deeks SG, Lu J, Hoh R, et al. Interruption of enfuvirtide in HIV-1 infected adults with incomplete viral suppression on an enfuvirtide-based regimen. *J Infect Dis*. 2007;195(3):387-391. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17205477](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17205477).
34. Wirden M, Simon A, Schneider L, et al. Raltegravir has no residual antiviral activity in vivo against HIV-1 with resistance-associated mutations to this drug. *J Antimicrob Chemother*. 2009;64(5):1087-1090. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19717396](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19717396).
35. Hicks CB, Cahn P, Cooper DA, et al. Durable efficacy of tipranavir-ritonavir in combination with an optimised background regimen of antiretroviral drugs for treatment-experienced HIV-1-infected patients at 48 weeks in the Randomized Evaluation of Strategic Intervention in multi-drug reSistant patients with Tipranavir (RESIST) studies: an analysis of combined data from two randomised open-label trials. *Lancet*. 2006;368(9534):466-475. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=16890833](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16890833).
36. Molina JM, Lamarca A, Andrade-Villanueva J, et al. Efficacy and safety of once daily elvitegravir versus twice daily raltegravir in treatment-experienced patients with HIV-1 receiving a ritonavir-boosted protease inhibitor: randomised, double-blind, phase 3, non-inferiority study. *Lancet Infect Dis*. 2012;12(1):27-35. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22015077>.
37. Cahn P, Andrade-Villanueva J, Arribas JR, et al. Dual therapy with lopinavir and ritonavir plus lamivudine versus triple therapy with lopinavir and ritonavir plus two nucleoside reverse transcriptase inhibitors in antiretroviral-therapy-naïve adults with HIV-1 infection: 48 week results of the randomised, open label, non-inferiority GARDEL trial. *Lancet Infect Dis*. 2014;14(7):572-580. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24783988>.
38. Raffi F, Babiker AG, Richert L, et al. Ritonavir-boosted darunavir combined with raltegravir or tenofovir-emtricitabine in antiretroviral-naïve adults infected with HIV-1: 96 week results from the NEAT001/ANRS143 randomised non-inferiority trial. *Lancet*. 2014;384(9958):1942-1951. Available at <http://www.ncbi.nlm.nih.gov/pubmed/25103176>.
39. Second-Line Study Group, Boyd MA, Kumarasamy N, et al. Ritonavir-boosted lopinavir plus nucleoside or nucleotide reverse transcriptase inhibitors versus ritonavir-boosted lopinavir plus raltegravir for treatment of HIV-1 infection in adults with virological failure of a standard first-line ART regimen (SECOND-LINE): a randomised, open-label, non-inferiority study. *Lancet*. 2013;381(9883):2091-2099. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23769235>.
40. Paton NI, Kityo C, Hoppe A, et al. Assessment of second-line antiretroviral regimens for HIV therapy in Africa. *N Engl J Med*. 2014;371(3):234-247. Available at <http://www.ncbi.nlm.nih.gov/pubmed/25014688>.
41. Prezista [package insert]. Food and Drug Administration. 2013. Available at [http://www.accessdata.fda.gov/drugsatfda\\_docs/label/2013/021976s033\\_202895s010lbl.pdf](http://www.accessdata.fda.gov/drugsatfda_docs/label/2013/021976s033_202895s010lbl.pdf). Accessed February 11, 2014.
42. Tivicay [package insert]. Food and Drug Administration. 2013. Available at [http://www.accessdata.fda.gov/drugsatfda\\_docs/label/2013/204790lbl.pdf](http://www.accessdata.fda.gov/drugsatfda_docs/label/2013/204790lbl.pdf). Accessed February 11, 2014.
43. Second-Line Study Group, Boyd MA, Kumarasamy N, et al. Ritonavir-boosted lopinavir plus nucleoside or nucleotide reverse transcriptase inhibitors versus ritonavir-boosted lopinavir plus raltegravir for treatment of HIV-1 infection in adults with virological failure of a standard first-line ART regimen (SECOND-LINE): a randomised, open-label, non-inferiority study. *Lancet*. 2013;381(9883):2091-2099. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23769235>.
44. Bunupuradah T, Chetchotisakd P, Ananworanich J, et al. A randomized comparison of second-line lopinavir/ritonavir monotherapy versus tenofovir/lamivudine/lopinavir/ritonavir in patients failing NNRTI regimens: the HIV STAR study. *Antivir Ther*. 2012;17(7):1351-1361. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23075703>.
45. Paton NI, Kityo C, Hoppe A. A pragmatic randomised controlled strategy trial of three second-line treatment options for use in public health rollout programme settings: the Europe-Africa Research Network for Evaluation of Second-line Therapy (EARNEST) Trial. Abstract WELBB02.2013. Presented at: 7th International AIDS Society Conference on HIV Pathogenesis, Treatment and Prevention (IAS 2013). 2013. Kuala Lumpur, Malaysia.
46. Lathouwers E, De Meyer S, Dierynck I, et al. Virological characterization of patients failing darunavir/ritonavir or lopinavir/ritonavir treatment in the ARTEMIS study: 96-week analysis. *Antivir Ther*. 2011;16(1):99-108. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=21311113](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=21311113).



47. Stebbing J, Nathan B, Jones R, et al. Virological failure and subsequent resistance profiles in individuals exposed to atazanavir. *AIDS*. 2007;21(13):1826-1828. Available at <http://www.ncbi.nlm.nih.gov/pubmed/17690587>.
48. Zheng Y, Lambert C, Arendt V, Seguin-Devaux C. Virological and immunological outcomes of elvitegravir-based regimen in a treatment-naïve HIV-2-infected patient. *AIDS*. 2014;28(15):2329-2331. Available at <http://www.ncbi.nlm.nih.gov/pubmed/25313590>.
49. White KL, Raffi F, Miller MD. Resistance analyses of integrase strand transfer inhibitors within phase 3 clinical trials of treatment-naïve patients. *Viruses*. 2014;6(7):2858-2879. Available at <http://www.ncbi.nlm.nih.gov/pubmed/25054884>.
50. De Luca A, Dunn D, Zazzi M, et al. Declining prevalence of HIV-1 drug resistance in antiretroviral treatment-exposed individuals in Western Europe. *J Infect Dis*. 2013;207(8):1216-1220. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23315324>.
51. Paquet AC, Solberg OD, Napolitano LA, et al. A decade of HIV-1 drug resistance in the United States: trends and characteristics in a large protease/reverse transcriptase and co-receptor tropism database from 2003 to 2012. *Antivir Ther*. 2014;19(4):435-441. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24518099>.
52. Murray JS, Elashoff MR, Iacono-Connors LC, Cvetkovich TA, Struble KA. The use of plasma HIV RNA as a study endpoint in efficacy trials of antiretroviral drugs. *AIDS*. 1999;13(7):797-804. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=10357378](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=10357378).
53. Miller V, Sabin C, Hertogs K, et al. Virological and immunological effects of treatment interruptions in HIV-1 infected patients with treatment failure. *AIDS*. 2000;14(18):2857-2867. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=11153667](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11153667).
54. Ledergerber B, Lundgren JD, Walker AS, et al. Predictors of trend in CD4-positive T-cell count and mortality among HIV-1-infected individuals with virological failure to all three antiretroviral-drug classes. *Lancet*. 2004;364(9428):51-62. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=15234856](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15234856).
55. Raffanti SP, Fusco JS, Sherrill BH, et al. Effect of persistent moderate viremia on disease progression during HIV therapy. *J Acquir Immune Defic Syndr*. 2004;37(1):1147-1154. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=15319674](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15319674).
56. Canestri A, Lescure FX, Jaureguierry S, et al. Discordance between cerebral spinal fluid and plasma HIV replication in patients with neurological symptoms who are receiving suppressive antiretroviral therapy. *Clin Infect Dis*. 2010;50(5):773-778. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=20100092](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20100092).
57. Peluso MJ, Ferretti F, Peterson J, et al. Cerebrospinal fluid HIV escape associated with progressive neurologic dysfunction in patients on antiretroviral therapy with well controlled plasma viral load. *AIDS*. 2012;26(14):1765-1774. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22614889>.
58. Letendre S. Central nervous system complications in HIV disease: HIV-associated neurocognitive disorder. *Top Antivir Med*. 2011;19(4):137-142. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22156215>.
59. Letendre SL, Mills AM, Tashima KT, et al. IN116070: a study of the pharmacokinetics and antiviral activity of dolutegravir in cerebrospinal fluid in HIV-1-infected, antiretroviral therapy-naïve subjects. *Clin Infect Dis*. 2014;59(7):1032-1037. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24944232>.
60. Calcagno A, Di Perri G, Bonora S. Pharmacokinetics and pharmacodynamics of antiretrovirals in the central nervous system. *Clin Pharmacokinet*. 2014;53(10):891-906. Available at <http://www.ncbi.nlm.nih.gov/pubmed/25200312>.
61. Moling O, Rossi P, Rimenti G, Vedovelli C, Mian P. Varicella-zoster virus meningitis and cerebrospinal fluid HIV RNA. *Scand J Infect Dis*. 2001;33(5):398-399. Available at <http://www.ncbi.nlm.nih.gov/pubmed/11440237>.
62. Eden A, Fuchs D, Hagberg L, et al. HIV-1 viral escape in cerebrospinal fluid of subjects on suppressive antiretroviral treatment. *J Infect Dis*. 2010;202(12):1819-1825. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=21050119](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=21050119).
63. Heaton RK, Franklin DR, Ellis RJ, et al. HIV-associated neurocognitive disorders before and during the era of combination antiretroviral therapy: differences in rates, nature, and predictors. *J Neurovirol*. 2011;17(1):3-16. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21174240>.
64. Ellis RJ, Letendre S, Vaida F, et al. Randomized trial of central nervous system-targeted antiretrovirals for HIV-associated neurocognitive disorder. *Clin Infect Dis*. 2014;58(7):1015-1022. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24352352>.

## Poor CD4 Cell Recovery and Persistent Inflammation Despite Viral Suppression (Last updated April 8, 2015; last reviewed April 8, 2015)

### Panel's Summary and Recommendations

- Morbidity and mortality from several AIDS and non-AIDS conditions are increased in HIV-infected individuals despite antiretroviral therapy (ART)-mediated viral suppression, and are predicted by persistently low CD4 T lymphocyte (CD4) cell counts and/or persistent immune activation.
- ART intensification by adding antiretroviral (ARV) drugs to a suppressive ART regimen does not consistently improve CD4 cell recovery or reduce immune activation and is not recommended (**AI**).
- In individuals with viral suppression, switching ARV drug classes does not consistently improve CD4 cell recovery or reduce immune activation and is not recommended (**BIII**).
- No interventions designed to increase CD4 cell counts and/or decrease immune activation are recommended at this time (in particular, interleukin-2 is **not recommended [AI]**) because none has been proven to decrease morbidity or mortality during ART-mediated viral suppression.
- Monitoring markers of immune activation and inflammation is not recommended because no immunologically targeted intervention has proven to improve the health of individuals with abnormally high biomarker levels, and many markers that predict morbidity and mortality fluctuate widely in individuals (**AII**).
- Because there are no proven interventions to improve CD4 cell recovery and/or inflammation, efforts should focus on addressing modifiable risk factors for chronic disease (e.g., encouraging smoking cessation, a healthy diet, and exercise; treating hypertension, hyperlipidemia) (**AII**).

**Rating of Recommendations:** A = Strong; B = Moderate; C = Optional

**Rating of Evidence:** I = Data from randomized controlled trials; II = Data from well-designed nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion

Despite marked improvements in antiretroviral treatment (ART), morbidity and mortality in HIV-infected individuals continues to be greater than in the general population, particularly when ART is delayed until advanced disease stages. These morbidities include cardiovascular disease, many non-AIDS cancers, non-AIDS infections, chronic obstructive pulmonary disease, osteoporosis, type II diabetes, thromboembolic disease, liver disease, renal disease, neurocognitive dysfunction, and frailty.<sup>1</sup> Although health-related behaviors and toxicities of antiretroviral (ARV) drugs may also contribute to the increased risk of illness and death, poor CD4 T lymphocyte (CD4) cell recovery, persistent immune activation, and inflammation likely also contribute to the risk.

### Poor CD4 Cell Recovery

As long as ART-mediated viral suppression is maintained, peripheral blood CD4 cell counts in most HIV-infected individuals will continue to increase for at least a decade. The rate of CD4 cell recovery is typically most rapid in the first 3 months of suppressive ART, followed by more gradual increases over time.<sup>2-4</sup> If ART-mediated viral suppression is maintained, most individuals will eventually recover CD4 counts in the normal range ( $>500$  cells/mm<sup>3</sup>); however, approximately 15% to 20% of individuals who initiate ART at very low CD4 counts ( $<200$  cells/mm<sup>3</sup>) may plateau at abnormally low CD4 cell counts.<sup>3-5</sup> Early initiation of ART in recently HIV-infected individuals likely provides the best opportunity for maximal CD4 cell recovery.<sup>6</sup>

Persistently low CD4 cell counts despite ART-mediated viral suppression are associated with increased risk of morbidity and mortality. For example, HIV-infected individuals with CD4 counts  $<200$  cells/mm<sup>3</sup> despite at least 3 years of suppressive ART had a 2.6-fold greater risk of mortality than those with higher CD4 cell counts.<sup>7</sup> Lower CD4 cell counts during ART-mediated viral suppression are associated with an increased risk

of non-AIDS morbidity and mortality,<sup>8-11</sup> including cardiovascular disease,<sup>12</sup> osteoporosis and fractures,<sup>13</sup> liver disease,<sup>14</sup> and infection-related cancers.<sup>15</sup> The prognostic importance of higher CD4 cell counts likely spans all ranges of CD4 cell counts, though incremental benefits are harder to discern once CD4 counts increase to >500 cells/mm<sup>3</sup>.<sup>16</sup>

Individuals with poor CD4 cell recovery should be evaluated for modifiable causes of CD4 cell lymphopenia. Concomitant medications should be reviewed, with a focus on those known to decrease white blood cells or, specifically, CD4 cells (e.g., cancer chemotherapy, interferon, zidovudine,<sup>17</sup> or the combination of tenofovir disoproxil fumarate (TDF) and didanosine (ddI).<sup>18,19</sup> If possible, these drugs should be substituted for or discontinued. Untreated coinfections (e.g., HCV, HIV-2) and serious medical conditions (e.g., malignancy) should also be considered as possible causes of CD4 lymphopenia, particularly in individuals with consistently declining CD4 cell counts (and percentages) and/or in those with CD4 counts consistently below 100 cells/mm<sup>3</sup>. In many cases, no obvious cause for suboptimal immunologic response can be identified.

Despite strong evidence linking low CD4 cell counts and increased morbidity during ART-mediated viral suppression, no adjunctive therapies that increase CD4 cell count beyond levels achievable with ART alone have been proven to decrease morbidity or mortality. Adding ARV drugs to an already suppressive ART regimen does not improve CD4 cell recovery,<sup>20-25</sup> and does not reduce morbidity or mortality. Therefore, ART intensification is not recommended as a strategy to improve CD4 cell recovery (**AI**). In individuals maintaining viral suppression, switching ARV drug classes in a suppressive regimen also does not consistently improve CD4 cell recovery and is not recommended (**BIII**).<sup>26</sup> Two large clinical trials, powered to assess impact on clinical endpoints (AIDS and death), evaluated the role of interleukin-2, an immune-based therapy, in improving CD4 cell recovery. Interleukin-2 adjunctive therapy resulted in CD4 cell count increases but with no observable clinical benefit. Therefore, interleukin-2 is **not recommended (AI)**.<sup>27</sup> Other immune-based therapies that increase CD4 cell counts (e.g., growth hormone, interleukin-7) are under investigation. However, none of the therapies have been evaluated in clinical endpoint trials; therefore, whether any of these approaches will offer clinical benefit is unclear. Currently, such immune-based therapies should not be used except in the context of a clinical trial.

### ***Persistent Immune Activation and Inflammation***

Although poor CD4 cell recovery likely contributes to morbidity and mortality during ART-mediated viral suppression, there is increasing focus on persistent immune activation and inflammation as potentially independent mediators of risk. HIV infection results in heightened systemic immune activation and inflammation, effects that are evident during acute infection, persist throughout chronic untreated infection, and predict more rapid CD4 cell decline and progression to AIDS and death, independent of plasma HIV RNA levels.<sup>28</sup> Although immune activation declines with suppressive ART, it often persists at abnormal levels in many HIV-infected individuals maintaining long-term ART-mediated viral suppression—even in those with CD4 cell recovery to normal levels.<sup>29,30</sup> Immune activation and inflammatory markers (e.g., IL-6, D-dimer, hs-CRP) also predict mortality and non-AIDS morbidity during ART-mediated viral suppression, including cardiovascular and thromboembolic events, cancer, neurocognitive dysfunction, and frailty.<sup>28</sup> Although individuals with poor CD4 cell recovery (i.e., counts persistently <350 cells/mm<sup>3</sup>) tend to have greater immune activation and inflammation than those with greater recovery,<sup>29</sup> the relationship between innate immune activation and inflammation and morbidity/mortality is largely independent of CD4 cell count.<sup>31,32</sup> Even in individuals with CD4 counts >500 cells/mm<sup>3</sup>, there is evidence that immune activation and inflammation contribute to morbidity and mortality.<sup>33</sup> Thus, innate immune activation and inflammation are potentially important targets for future interventions.

Although the drivers of persistent immune activation during ART are not completely understood, HIV persistence, coinfections, and microbial translocation likely play important roles.<sup>28</sup> Interventions to reduce each of these presumed drivers are currently being investigated. Importantly, adding ARV drugs to an already

suppressive ART regimen (ART intensification) does not consistently improve immune activation.<sup>20-23,25</sup> Although some studies have suggested that switching an ART regimen to one with a more favorable lipid profile may improve some markers of immune activation and inflammation,<sup>34,35</sup> these studies have limitations and results are not consistent across markers and among studies. Thus, at this time, ART modification cannot be recommended as a strategy to reduce immune activation (**BIII**). Other commonly used medications with anti-inflammatory properties (e.g., statins, aspirin) are being studied, and preliminary evidence suggests that some may reduce immune activation in treated HIV infection.<sup>36,37</sup> However, because no intervention specifically targeting immune activation or inflammation has been studied in a clinical outcomes trial in treated HIV infection, no interventions to reduce immune activation are recommended at this time.

In the absence of proven interventions, there is currently no clear rationale to monitor levels of immune activation and inflammation in treated HIV infection. Furthermore, many of the inflammatory markers that predict morbidity and mortality fluctuate significantly in HIV-infected individuals. Thus, clinical monitoring with immune activation or inflammatory markers is **not currently recommended** (**AII**). The focus of care to reduce chronic non-AIDS morbidity and mortality should be on maintaining ART-mediated viral suppression and addressing strategies to reduce risk factors (e.g., smoking cessation, healthy diet, and exercise) and managing chronic comorbidities such as hypertension, hyperlipidemia, and diabetes (**AII**).

## References

1. Deeks SG. HIV infection, inflammation, immunosenescence, and aging. *Annu Rev Med*. 2011;62:141-155. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21090961>.
2. Bartlett JA, DeMasi R, Quinn J, Moxham C, Rousseau F. Overview of the effectiveness of triple combination therapy in antiretroviral-naïve HIV-1 infected adults. *AIDS*. 2001;15(11):1369-1377. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=11504958](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11504958).
3. Kelley CF, Kitchen CM, Hunt PW, et al. Incomplete peripheral CD4+ cell count restoration in HIV-infected patients receiving long-term antiretroviral treatment. *Clin Infect Dis*. 2009;48(6):787-794. Available at <http://www.ncbi.nlm.nih.gov/pubmed/19193107>.
4. Lok JJ, Bosch RJ, Benson CA, et al. Long-term increase in CD4+ T-cell counts during combination antiretroviral therapy for HIV-1 infection. *AIDS*. 2010;24(12):1867-1876. Available at <http://www.ncbi.nlm.nih.gov/pubmed/20467286>.
5. Moore RD, Keruly JC. CD4+ cell count 6 years after commencement of highly active antiretroviral therapy in persons with sustained virologic suppression. *Clin Infect Dis*. 2007;44(3):441-446. Available at <http://www.ncbi.nlm.nih.gov/pubmed/17205456>.
6. Le T, Wright EJ, Smith DM, et al. Enhanced CD4+ T-cell recovery with earlier HIV-1 antiretroviral therapy. *N Engl J Med*. 2013;368(3):218-230. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23323898>.
7. Engsig FN, Zangerle R, Katsarou O, et al. Long-term mortality in HIV-positive individuals virally suppressed for >3 years with incomplete CD4 recovery. *Clin Infect Dis*. 2014;58(9):1312-1321. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24457342>.
8. Lewden C, Bouteloup V, De Wit S, et al. All-cause mortality in treated HIV-infected adults with CD4  $\geq 500/\text{mm}^3$  compared with the general population: evidence from a large European observational cohort collaboration {dagger}. *Int J Epidemiol*. 2012;41(2):433-445. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22493325>.
9. Baker JV, Peng G, Rapkin J, et al. CD4+ count and risk of non-AIDS diseases following initial treatment for HIV infection. *AIDS*. 2008;22(7):841-848. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18427202](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18427202).
10. Achhra AC, Amin J, Law MG, et al. Immunodeficiency and the risk of serious clinical endpoints in a well studied cohort of treated HIV-infected patients. *AIDS*. 2010;24(12):1877-1886. Available at <http://www.ncbi.nlm.nih.gov/pubmed/20588170>.
11. Smurzynski M, Wu K, Benson CA, Bosch RJ, Collier AC, Koletar SL. Relationship between CD4+ T-cell counts/HIV-1 RNA plasma viral load and AIDS-defining events among persons followed in the ACTG longitudinal linked randomized trials study. *J Acquir Immune Defic Syndr*. 2010;55(1):117-127. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=20622677](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20622677).



12. Lichtenstein KA, Armon C, Buchacz K, et al. Low CD4+ T cell count is a risk factor for cardiovascular disease events in the HIV outpatient study. *Clin Infect Dis*. 2010;51(4):435-447. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=20597691](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20597691).
13. Yong MK, Elliott JH, Woolley IJ, Hoy JF. Low CD4 count is associated with an increased risk of fragility fracture in HIV-infected patients. *J Acquir Immune Defic Syndr*. 2011;57(3):205-210. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21522014>.
14. Weber R, Sabin CA, Friis-Moller N, et al. Liver-related deaths in persons infected with the human immunodeficiency virus: the D:A:D study. *Arch Intern Med*. 2006;166(15):1632-1641. Available at <http://www.ncbi.nlm.nih.gov/pubmed/16908797>.
15. Monforte A, Abrams D, Pradier C, et al. HIV-induced immunodeficiency and mortality from AIDS-defining and non-AIDS-defining malignancies. *AIDS*. 2008;22(16):2143-2153. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18832878](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18832878).
16. Young J, Psychogiou M, Meyer L, et al. CD4 cell count and the risk of AIDS or death in HIV-Infected adults on combination antiretroviral therapy with a suppressed viral load: a longitudinal cohort study from COHERE. *PLoS Med*. 2012;9(3):e1001194. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22448150>.
17. Huttner AC, Kaufmann GR, Battegay M, Weber R, Opravil M. Treatment initiation with zidovudine-containing potent antiretroviral therapy impairs CD4 cell count recovery but not clinical efficacy. *AIDS*. 2007;21(8):939-946. Available at <http://www.ncbi.nlm.nih.gov/pubmed/17457087>.
18. Barrios A, Rendon A, Negredo E, et al. Paradoxical CD4+ T-cell decline in HIV-infected patients with complete virus suppression taking tenofovir and didanosine. *AIDS*. 2005;19(6):569-575. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=15802975](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15802975).
19. Negredo E, Bonjoch A, Paredes R, Puig J, Clotet B. Compromised immunologic recovery in treatment-experienced patients with HIV infection receiving both tenofovir disoproxil fumarate and didanosine in the TORO studies. *Clin Infect Dis*. 2005;41(6):901-905. Available at <http://www.ncbi.nlm.nih.gov/pubmed/16107993>.
20. Gandhi RT, Zheng L, Bosch RJ, et al. The effect of raltegravir intensification on low-level residual viremia in HIV-infected patients on antiretroviral therapy: a randomized controlled trial. *PLoS Med*. 2010;7(8). Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=20711481](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20711481).
21. Hatano H, Strain MC, Scherzer R, et al. Increase in 2-Long Terminal Repeat Circles and Decrease in D-dimer After Raltegravir Intensification in Patients With Treated HIV Infection: A Randomized, Placebo-Controlled Trial. *The Journal of Infectious Diseases*. 2013;208(9):1436-1442. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23975885>.
22. Hunt PW, Shulman NS, Hayes TL, et al. The immunologic effects of maraviroc intensification in treated HIV-infected individuals with incomplete CD4+ T-cell recovery: a randomized trial. *Blood*. 2013;121(23):4635-4646. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23589670>.
23. Dinso JB, Kim SY, Wiegand AM, et al. Treatment intensification does not reduce residual HIV-1 viremia in patients on highly active antiretroviral therapy. *Proc Natl Acad Sci U S A*. 2009;106(23):9403-9408. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19470482](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19470482).
24. Cuzin L, Trabelsi S, Delobel P, et al. Maraviroc intensification of stable antiviral therapy in HIV-1-infected patients with poor immune restoration: MARIMUNO-ANRS 145 study. *J Acquir Immune Defic Syndr*. 2012;61(5):557-564. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22986949>.
25. Buzon MJ, Massanella M, Llibre JM, et al. HIV-1 replication and immune dynamics are affected by raltegravir intensification of HAART-suppressed subjects. *Nat Med*. 2010;16(4):460-465. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=20228817](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20228817).
26. Martinez E, Larrousse M, Llibre JM, et al. Substitution of raltegravir for ritonavir-boosted protease inhibitors in HIV-infected patients: the SPIRAL study. *AIDS*. 2010;24(11):1697-1707. Available at <http://www.ncbi.nlm.nih.gov/pubmed/20467288>.
27. Abrams D, Levy Y, Losso MH, et al. Interleukin-2 therapy in patients with HIV infection. *N Engl J Med*. 2009;361(16):1548-1559. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19828532](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19828532).
28. Lederman MM, Funderburg NT, Sekaly RP, Klatt NR, Hunt PW. Residual immune dysregulation syndrome in treated HIV infection. *Adv Immunol*. 2013;119:51-83. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23886064>.
29. Lederman MM, Calabrese L, Funderburg NT, et al. Immunologic failure despite suppressive antiretroviral therapy is related to activation and turnover of memory CD4 cells. *J Infect Dis*. 2011;204(8):1217-1226. Available at



<http://www.ncbi.nlm.nih.gov/pubmed/21917895>.

30. Hunt PW, Martin JN, Sinclair E, et al. T cell activation is associated with lower CD4+ T cell gains in human immunodeficiency virus-infected patients with sustained viral suppression during antiretroviral therapy. *J Infect Dis*. 2003;187(10):1534-1543. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=12721933](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=12721933).
31. Hunt PW, Sinclair E, Rodriguez B, et al. Gut Epithelial Barrier Dysfunction and Innate Immune Activation Predict Mortality in Treated HIV Infection. *J Infect Dis*. 2014. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24755434>.
32. Tenorio AR, Zheng Y, Bosch RJ, et al. Soluble Markers of Inflammation and Coagulation but Not T-Cell Activation Predict Non-AIDS-Defining Morbid Events During Suppressive Antiretroviral Treatment. *J Infect Dis*. 2014. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24795473>.
33. Tien PC, Choi AI, Zolopa AR, et al. Inflammation and mortality in HIV-infected adults: analysis of the FRAM study cohort. *J Acquir Immune Defic Syndr*. 2010;55(3):316-322. Available at <http://www.ncbi.nlm.nih.gov/pubmed/20581689>.
34. Martinez E, D'Albuquerque PM, Llibre JM, et al. Changes in cardiovascular biomarkers in HIV-infected patients switching from ritonavir-boosted protease inhibitors to raltegravir. *AIDS*. 2012;26(18):2315-2326. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23018438>.
35. Lake JE, McComsey GA, Hulgren T, et al. Switch to raltegravir decreases soluble CD14 in virologically suppressed overweight women: the Women, Integrase and Fat Accumulation Trial. *HIV Med*. 2014;15(7):431-441. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24506429>.
36. Funderburg NT, Jiang Y, Debanne SM, et al. Rosuvastatin treatment reduces markers of monocyte activation in HIV-infected subjects on antiretroviral therapy. *Clin Infect Dis*. 2014;58(4):588-595. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24253250>.
37. O'Brien M, Montenont E, Hu L, et al. Aspirin attenuates platelet activation and immune activation in HIV-infected subjects on antiretroviral therapy: a pilot study. *J Acquir Immune Defic Syndr*. 2013. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23406976>.

## Regimen Switching In the Setting of Virologic Suppression (Last updated May 1, 2014; last reviewed May 1, 2014)

With use of currently available antiretroviral therapy (ART), most HIV-infected patients are able to achieve sustained HIV viral suppression. Furthermore, advances in treatment and better understanding about drug resistance make it possible to consider switching an effective regimen to an alternative regimen in some situations (see below). When contemplating such a switch, clinicians must consider several key principles to maintain viral suppression while addressing concerns with the current treatment.

### Reasons to Consider Regimen Switching in the Setting of Viral Suppression:

- To simplify the regimen by reducing pill burden and dosing frequency to improve adherence
- To enhance tolerability and decrease short- or long-term toxicity (see [Adverse Effects](#) section)
- To change food or fluid requirements
- To avoid parenteral administration
- To minimize or address drug interaction concerns (see [Drug Interactions](#) section)
- To allow for optimal use of ART during pregnancy or should pregnancy occur (see [Perinatal Guidelines](#))<sup>1</sup>
- To reduce costs (see [Cost](#) section)

### ***Principles and Strategies of Regimen Switching***

The cardinal principle of regimen switching is to maintain viral suppression without jeopardizing future treatment options. If a regimen switch results in virologic failure with emergence of new resistance mutations, the patient may require more complex, difficult to follow, or expensive regimens. Principles for successful regimen switching are highlighted below:

- It is critical to review a patient's full antiretroviral (ARV) history (including virologic responses, resistance test results, and past adverse events) before any treatment switch.
- Once a particular resistance mutation has been selected, it is generally archived in the HIV reservoir and is likely to reappear under the appropriate selective drug pressure, even if not detected in the most recent resistance test. If resistance data are unavailable, resistance may often be inferred from a patient's treatment history. For example, a clinician should assume that patients who have failed a cytosine analogue (e.g., a lamivudine (3TC)- or emtricitabine (FTC)-containing regimen), likely have the M184V substitution, even if the substitution is not documented. The same assumption of resistance may also apply to patients with documented failure to a non-nucleoside reverse transcriptase inhibitor (NNRTI)- or an integrase strand transfer inhibitors (INSTI)-based regimen because these drugs generally have a lower barrier to resistance. If there is uncertainty about prior resistance, it is generally not advisable to switch a suppressive ARV regimen unless the new regimen is likely to be as active against resistant virus as the suppressive regimen.
- Consultation with an HIV specialist is recommended when considering a regimen switch for a patient with a history of resistance to one or more drug classes.
- Switching from a ritonavir (RTV)-boosted protease inhibitor (PI) regimen to a regimen composed of drugs with a lower barrier to resistance generally maintains viral suppression provided there is no resistance to the other components of the regimen. However, such switches should be avoided if there is any doubt about the activity of the other agents in the regimen.
- Within-class switches prompted by adverse events usually maintain viral suppression provided that there is no drug resistance to the other ARV agents in the same drug class.

- In the absence of any likely drug resistance, switching from complex regimens, parenteral drug (i.e., enfuvirtide), or drugs known now to be more toxic (e.g., zidovudine, stavudine, or didanosine) or with higher pill burden or dosing frequency to simpler regimens (e.g., from a regimen including ritonavir-boosted saquinavir [SQV/r] to one including ritonavir-boosted darunavir [DRV/r]) or to ARVs in a new drug class (e.g., an INSTI) generally results in similar or improved adherence, continued viral suppression and possibly improved quality of life.
- More intensive monitoring of tolerability, viral suppression, adherence, and laboratory changes is recommended during the first 3 months after a regimen switch.

## ***Alternative Switch Strategies for Patients with Virologic Suppression***

### **RTV-Boosted PI Monotherapy**

The strategy of switching virologically suppressed patients without PI resistance from one ART regimen to RTV-boosted PI monotherapy has been studied. The rationale for this strategy is to avoid nucleoside reverse transcriptase inhibitor (NRTI) toxicities and decrease costs, while taking advantage of the high barrier to resistance of RTV-boosted PIs. RTV-boosted PI monotherapy maintains virologic suppression in most patients, but at slightly lower rates than standard therapy that includes 2 NRTIs.<sup>2,3</sup> Low-level viremia, generally without the emergence of PI resistance, appears to be more common with monotherapy. In most studies, resumption of NRTIs in patients experiencing low level viral rebound has led to re-suppression.

No clinical trials comparing available RTV-boosted PI monotherapy regimens have been conducted. Findings from an observational study suggest that the rate of treatment failure is higher in patients on RTV-boosted atazanavir (ATV/r) than in those on RTV-boosted lopinavir (LPV/r) or DRV/r.<sup>4</sup> Another pilot study reported early viral rebound with use of ATV/r monotherapy.<sup>5</sup> There are rare reports of central nervous system virologic escape, sometimes with clinical symptoms, in patients on RTV-boosted PI monotherapy.<sup>6,7</sup>

On the basis of the results from these studies, RTV-boosted PI monotherapy should generally be avoided. Other strategies to avoid use of NRTIs (i.e., use of a RTV-boosted PI plus a NNRTI, an INSTI, or maraviroc [MVC]) are also being studied, but data on these strategies are limited.

### **Switching from a Ritonavir-Boosted Protease Inhibitor to Unboosted Atazanavir**

Several clinical studies have evaluated switching a RTV-boosted PI to unboosted atazanavir (ATV) in virologically suppressed patients without NRTI resistance. Two comparative clinical trials reported that ATV/r and ATV, both in combination with 2 NRTIs (mostly ABC/3TC), demonstrated comparable levels of virologic suppression and a similar lack of treatment-emergent resistance. The benefits of the unboosted ATV regimen included a slightly improved lipid profile and a lower incidence of hyperbilirubinemia.<sup>8,9</sup> An additional study of 296 patients with virologic suppression on tenofovir disoproxil fumarate (TDF)/FTC plus ATV/r showed that patients switched to ABC/3TC plus ATV maintained viral suppression and showed improvements in certain bone and renal biomarkers.<sup>10</sup> The results of these and other non-comparative studies suggest that a regimen of ABC/3TC plus ATV can be considered in virologically suppressed patients, especially in those who have adverse effects from TDF or RTV.

### **Switching to Maraviroc**

Co-receptor usage in virologically suppressed patients can be determined from proviral DNA obtained from peripheral blood mononuclear cells. Individuals found to have R5-tropic virus by this technique could potentially have a component of their regimens switched to MVC.<sup>11,12</sup> However, although the use of MVC after DNA tropism testing has potential, this strategy cannot be recommended until more data from larger clinical studies are available (see [Tropism Testing](#) section).

## De-intensification

De-intensification of a standard RTV-boosted PI regimen from three to two active drugs (e.g., to a boosted PI plus one NRTI,<sup>13</sup> a boosted PI plus an INSTI,<sup>14,15</sup> or an NNRTI such as etravirine<sup>15</sup> or the CCR5 antagonist MVC<sup>12</sup>) may be more effective virologically than RTV-boosted PI monotherapy, but, thus far, comparative data on this approach are limited. In general, switching a regimen—even in a patient without known drug resistance—from an effective three-drug regimen to a two-drug regimen has not been validated and is not recommended.

## Monitoring After Treatment Changes

Patients should be evaluated more closely for several months after a treatment switch (i.e., a clinic visit or phone call 1 to 2 weeks after the change and a viral load test to check for rebound viremia 4 to 8 weeks after the switch). The goal of the intensive monitoring is to assess medication tolerance and conduct targeted laboratory testing if the patient had pre-existing laboratory abnormalities or there are potential concerns with the new regimen. For example, if lipid abnormalities were present and/or were a reason for the ARV change or are a concern with the new regimen, fasting cholesterol subsets and triglycerides should be assessed within 3 months after the change in therapy. Absent any specific complaints, laboratory abnormalities, or evidence of viral rebound at this 3-month visit, clinical and laboratory monitoring of the patient may resume on a regularly scheduled basis (see [Laboratory Testing](#) section).

## References

1. Panel on Treatment of HIV-Infected Pregnant Women and Prevention of Perinatal Transmission. Recommendations for use of antiretroviral drugs in pregnant HIV-1-infected women for maternal health and interventions to reduce perinatal HIV transmission in the United States. Available at <http://aidsinfo.nih.gov/contentfiles/lvguidelines/PerinatalGL.pdf>.
2. Bierman WF, van Agtmael MA, Nijhuis M, Danner SA, Boucher CA. HIV monotherapy with ritonavir-boosted protease inhibitors: a systematic review. *AIDS*. 2009;23(3):279-291. Available at <http://www.ncbi.nlm.nih.gov/pubmed/19114854>.
3. Arribas JR, Clumeck N, Nelson M, Hill A, van Delft Y, Moecklinghoff C. The MONET trial: week 144 analysis of the efficacy of darunavir/ritonavir (DRV/r) monotherapy versus DRV/r plus two nucleoside reverse transcriptase inhibitors, for patients with viral load < 50 HIV-1 RNA copies/mL at baseline. *HIV Med*. 2012;13(7):398-405. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22413874>.
4. Guiguet M, Ghosn J, Duivier C, et al. Boosted protease inhibitor monotherapy as a maintenance strategy: an observational study. *AIDS*. 2012;26(18):2345-2350. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22695301>.
5. Karlstrom O, Josephson F, Sonnerborg A. Early virologic rebound in a pilot trial of ritonavir-boosted atazanavir as maintenance monotherapy. *J Acquir Immune Defic Syndr*. 2007;44(4):417-422. Available at <http://www.ncbi.nlm.nih.gov/pubmed/17159658>.
6. Katlama C, Valantin MA, Algarte-Genin M, et al. Efficacy of darunavir/ritonavir maintenance monotherapy in patients with HIV-1 viral suppression: a randomized open-label, noninferiority trial, MONOI-ANRS 136. *AIDS*. 2010;24(15):2365-2374. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=20802297](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20802297).
7. Vernazza P, Daneel S, Schiffer V, et al. The role of compartment penetration in PI-monotherapy: the Atazanavir-Ritonavir Monomaintenance (ATARITMO) Trial. *AIDS*. 2007;21(10):1309-1315. Available at <http://www.ncbi.nlm.nih.gov/pubmed/17545707>.
8. Squires KE, Young B, DeJesus E, et al. ARIES 144 week results: durable virologic suppression in HIV-infected patients simplified to unboosted atazanavir/abacavir/lamivudine. *HIV Clin Trials*. 2012;13(5):233-244. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23134624>.
9. Ghosn J, Carosi G, Moreno S, et al. Unboosted atazanavir-based therapy maintains control of HIV type-1 replication as effectively as a ritonavir-boosted regimen. *Antivir Ther*. 2010;15(7):993-1002. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21041914>.
10. Wohl D. Simplification to abacavir/lamivudine (ABC/3TC) + atazanavir (ATV) from tenofovir/emtricitabine (TDF/FTC) + ATV/Ritonavir (RTV, /r) maintains viral suppression and improves bone biomarkers. Abstract H-556c. Paper presented at: Interscience Conference on Antimicrobial Agents and Chemotherapy; 2012.

11. Bonjoch A, Pou C, Perez-Alvarez N, et al. Switching the third drug of antiretroviral therapy to maraviroc in aviraemic subjects: a pilot, prospective, randomized clinical trial. *J Antimicrob Chemother*. 2013;68(6):1382-1387. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23354282>.
12. Vitiello P, Brudney D, MacCartney M, et al. Responses to switching to maraviroc-based antiretroviral therapy in treated patients with suppressed plasma HIV-1-RNA load. *Intervirology*. 2012;55(2):172-178. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22286889>.
13. Di Giambenedetto S, Fabbiani M, Colafigli M, et al. Safety and feasibility of treatment simplification to atazanavir/ritonavir + lamivudine in HIV-infected patients on stable treatment with two nucleos(t)ide reverse transcriptase inhibitors + atazanavir/ritonavir with virological suppression (Atazanavir and Lamivudine for treatment Simplification, AtLaS pilot study). *J Antimicrob Chemother*. 2013;68(6):1364-1372. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23372058>.
14. Ofotokun I, Sheth AN, Sanford SE, et al. A switch in therapy to a reverse transcriptase inhibitor sparing combination of lopinavir/ritonavir and raltegravir in virologically suppressed HIV-infected patients: a pilot randomized trial to assess efficacy and safety profile: the KITE study. *AIDS Res Hum Retroviruses*. 2012;28(10):1196-1206. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22364141>.
15. Burgos J, Crespo M, Falco V, et al. Simplification to dual antiretroviral therapy including a ritonavir-boosted protease inhibitor in treatment-experienced HIV-1-infected patients. *J Antimicrob Chemother*. 2012;67(10):2479-2486. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22729925>.



## Exposure-Response Relationship and Therapeutic Drug Monitoring (TDM) for Antiretroviral Agents (Last updated April 8, 2015; last reviewed April 8, 2015)

### Panel's Recommendations

- Therapeutic drug monitoring for antiretroviral agents is not recommended for routine use in the management of HIV-infected patients (BII).
- TDM may be considered in selected clinical scenarios, as discussed in the text below.

**Rating of Recommendations:** A = Strong; B = Moderate; C = Optional

**Rating of Evidence:** I = Data from randomized controlled trials; II = Data from well-designed nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion

Knowledge about the relationship between a drug's systemic exposure (or concentration) and responses (beneficial and/or adverse) is key in selecting the dose of a drug, in understanding why patients may respond differently to the same drug and dose, and in designing strategies to optimize drug response and tolerability.

Therapeutic drug monitoring (TDM) is a strategy used to guide dosing of certain antiarrhythmics, anticonvulsants, antineoplastics, and antimicrobial agents by using measured drug concentrations to improve the likelihood of the desired therapeutic and safety outcomes. Drugs suitable for TDM are characterized by a known exposure-response relationship and a therapeutic range of concentrations. The therapeutic range is a range of concentrations established through clinical investigations that are associated with a greater likelihood of achieving the desired therapeutic response and/or reducing the frequency of drug-associated adverse reactions.

Several antiretroviral (ARV) agents meet most of the characteristics of agents suitable for a TDM strategy.<sup>1</sup> Specifically, some ARVs have considerable interpatient variability in drug concentrations; other ARVs have known drug concentrations associated with efficacy and/or toxicity; and in the case of other drugs, data from small prospective studies have demonstrated that TDM improved virologic response and/or decreased the incidence of concentration-related drug toxicities.<sup>2,3</sup>

**TDM for ARV agents, however, is not recommended for routine use in the management of HIV-infected adults (BII).** This recommendation is based on multiple factors that limit the routine use of TDM in HIV-infected patients. These limiting factors include lack of prospective studies that demonstrate routine use of TDM improves clinical outcomes, uncertain therapeutic thresholds for most ARV agents, great intra- and inter-patient variability in drug concentrations achieved, and a lack of commercial laboratories to perform real time quantitation of ARV concentrations.<sup>2-5</sup>

### ***Scenarios for Consideration of Therapeutic Drug Monitoring***

Although routine use of TDM is not recommended, in some scenarios, ARV concentration data may be useful in patient management. In these cases, assistance from a clinical pharmacologist or a clinical pharmacist to interpret the concentration data may be advisable. These scenarios include the following:

- Suspect clinically significant drug-drug or drug-food interactions that may result in reduced efficacy or increased dose-related toxicities;
- Changes in pathophysiologic states that may impair gastrointestinal, hepatic, or renal function, thereby potentially altering drug absorption, distribution, metabolism, or elimination;
- Among pregnant women who have risk factors for virologic failure (e.g., those not achieving viral suppression during earlier stage of pregnancy)—during the later stages of pregnancy, physiologic changes may result in reduced drug exposure and thus further increase the risk of virologic failure;

- Heavily pretreated patients experiencing virologic failure and who may have viral isolates with reduced susceptibility to ARVs;
- Use of alternative dosing regimens and ARV combinations for which safety and efficacy have not been established in clinical trials;
- Concentration-dependent, drug-associated toxicities; and
- Lack of expected virologic response in medication-adherent patients.

### ***Resources for Therapeutic Drug Monitoring Target Concentrations***

Most TDM-proposed target concentrations for ARVs focus on a minimum concentration ( $C_{\min}$ ) (i.e., the plasma concentration at the end of a dosing interval before the next ARV dose). A summary of population average ARV  $C_{\min}$  can be found in a review on the role of ARV-related TDM.<sup>2</sup> Population average  $C_{\min}$  for newer ARVs can be found in the Food and Drug Administration-approved product labels.

Guidelines for the collection of blood samples and other practical suggestions related to TDM can be found in a position paper by the Adult AIDS Clinical Trials Group Pharmacology Committee.<sup>4</sup>

### ***Challenges and Considerations in Using Drug Concentrations to Guide Therapy***

There are several challenges and considerations for implementation of TDM in the clinical setting. Use of TDM to monitor ARV concentrations in a patient requires the following:

- quantification of the concentration of the drug, usually in plasma or serum;
- determination of the patient's pharmacokinetic characteristics;
- integration of information on patient adherence;
- interpretation of the drug concentrations; and
- adjustment of the drug dose to achieve concentrations within the therapeutic range, if necessary.

A final caveat to the use of measured drug concentrations in patient management is a general one—drug concentration information cannot be used alone; it must be integrated with other clinical information, including the patient's ARV history and adherence before the TDM result. In addition, as knowledge of associations between ARV concentrations and virologic response evolves, clinicians who use a TDM strategy for patient management should evaluate the most up-to-date information regarding the exposure-response relationship of the tested ARV agent.

## **References**

1. Spector R, Park GD, Johnson GF, Vesell ES. Therapeutic drug monitoring. *Clin Pharmacol Ther.* 1988;43(4):345-353. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=3281773](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=3281773).
2. Pretorius E, Klinker H, Rosenkranz B. The role of therapeutic drug monitoring in the management of patients with human immunodeficiency virus infection. *Ther Drug Monit.* 2011;33(3):265-274. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21566505>.
3. Kredo T, Van der Walt JS, Siegfried N, Cohen K. Therapeutic drug monitoring of antiretrovirals for people with HIV. *Cochrane Database Syst Rev.* 2009(3):CD007268. Available at <http://www.ncbi.nlm.nih.gov/pubmed/19588422>.
4. Acosta EP, Gerber JG. Position paper on therapeutic drug monitoring of antiretroviral agents. *AIDS Res Hum Retroviruses.* 2002;18(12):825-834. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=12201904](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=12201904).
5. van Luin M, Kuks PF, Burger DM. Use of therapeutic drug monitoring in HIV disease. *Curr Opin HIV AIDS.* 2008;3(3):266-271. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19372977](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19372977).

## Discontinuation or Interruption of Antiretroviral Therapy (Last updated April 8, 2015; last reviewed April 8, 2015)

Discontinuation of antiretroviral therapy (ART) may result in viral rebound, immune decompensation, and clinical progression.<sup>1-5</sup> Thus, planned interruptions of ART are not generally recommended. However, unplanned interruption of ART may occur under certain circumstances as discussed below.

### ***Short-Term Therapy Interruptions***

Reasons for short-term interruption (days to weeks) of ART vary and may include drug toxicity; intercurrent illnesses that preclude oral intake, such as gastroenteritis or pancreatitis; surgical procedures; or interrupted access to drugs. Stopping ART for a short time (i.e., less than 1 to 2 days) because of a medical/surgical procedure can usually be done by holding all drugs in the regimen. Recommendations for some other scenarios are listed below:

#### **Unanticipated Short-Term Therapy Interruption**

*When a Patient Experiences a Severe or Life-Threatening Toxicity or Unexpected Inability to Take Oral Medications:*

- All components of the drug regimen should be stopped simultaneously, regardless of drug half-life.

#### **Planned Short-Term Therapy Interruption (Up to 2 Weeks)**

*When All Regimen Components Have Similar Half-Lives and Do Not Require Food for Proper Absorption:*

- All drugs may be given with a sip of water, if allowed; otherwise, all drugs should be stopped simultaneously. All discontinued regimen components should be restarted simultaneously.

*When All Regimen Components have Similar Half-Lives and Require Food for Adequate Absorption, and the Patient Cannot Take Anything by Mouth for a Short Time:*

- Temporary discontinuation of all drug components is indicated. The regimen should be restarted as soon as the patient can resume oral intake.

*When the ARV Regimen Contains Drugs with Different Half-Lives:*

- Stopping all drugs simultaneously may result in functional monotherapy with the drug with the longest half-life (typically a non-nucleoside reverse transcriptase inhibitor [NNRTI]), which may increase the risk of selection of NNRTI-resistant mutations. Some experts recommend stopping the NNRTI first and the other ARV drugs 2 to 4 weeks later. Alternatively, the NNRTI may be replaced with a ritonavir (or cobicistat)-boosted protease inhibitor (PI/r or PI/c) for 4 weeks. The optimal time sequence for staggered discontinuation of regimen components, or replacement of the NNRTI with a PI/r (or PI/c), has not been determined.

### ***Planned Long-Term Therapy Interruptions***

Planned long-term therapy interruptions are **not recommended** outside of controlled clinical trials (AI). Several research studies are evaluating approaches to a functional (virological control in the absence of therapy) or sterilizing (virus eradication) cure of HIV infection. Currently, the only way to reliably test the effectiveness of these strategies may be to interrupt ART and closely monitor viral rebound over time in the setting of a clinical trial.

If therapy must be discontinued, patients should be aware of and understand the risks of viral rebound, acute retroviral syndrome, increased risk of HIV transmission, decline of CD4 count, HIV disease progression, development of minor HIV-associated manifestations such as oral thrush or serious non-AIDS complications

(e.g., renal, cardiac, hepatic, or neurologic complications), development of drug resistance, and the need for chemoprophylaxis against opportunistic infections as a result of CD4 decline. Patients should be counseled about the need for close clinical and laboratory monitoring during therapy interruptions.

## References

1. Holkmann Olsen C, Mocroft A, Kirk O, et al. Interruption of combination antiretroviral therapy and risk of clinical disease progression to AIDS or death. *HIV Med.* 2007;8(2):96-104. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17352766](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17352766).
2. Kousignian I, Abgrall S, Grabar S, et al. Maintaining antiretroviral therapy reduces the risk of AIDS-defining events in patients with uncontrolled viral replication and profound immunodeficiency. *Clin Infect Dis.* 2008;46(2):296-304. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18171266](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18171266).
3. Danel C, Moh R, Minga A, et al. CD4-guided structured antiretroviral treatment interruption strategy in HIV-infected adults in west Africa (Trivacan ANRS 1269 trial): a randomised trial. *Lancet.* 2006;367(9527):1981-1989. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?db=pubmed&cmd=Retrieve&dopt=AbstractPlus&list\\_uids=16782488&itool=iconabstr&query\\_hl=147&itool=pubmed\\_docsum](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?db=pubmed&cmd=Retrieve&dopt=AbstractPlus&list_uids=16782488&itool=iconabstr&query_hl=147&itool=pubmed_docsum).
4. DART Trial Team DTT. Fixed duration interruptions are inferior to continuous treatment in African adults starting therapy with CD4 cell counts < 200 cells/microl. *AIDS.* 2008;22(2):237-247. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18097226](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18097226).
5. El-Sadr WM, Lundgren JD, Neaton JD, et al. CD4+ count-guided interruption of antiretroviral treatment. *N Engl J Med.* 2006;355(22):2283-2296. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17135583](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17135583).

# Considerations for Antiretroviral Use in Special Patient Populations

## Acute and Recent (Early<sup>a</sup>) HIV Infection (Last updated January 28, 2016; last reviewed January 28, 2016)

Panel's Recommendations
<ul style="list-style-type: none"><li>Antiretroviral therapy (ART) is recommended for all individuals with HIV-1 infection (<b>AI</b>) including those with early<sup>a</sup> HIV-1 infection.</li><li>Once initiated, the goal of ART is to suppress plasma HIV-1 RNA to undetectable levels (<b>AIII</b>). Testing for plasma HIV-1 RNA levels, CD4 T lymphocyte counts, and toxicity monitoring should be performed as recommended for patients with chronic HIV-1 infection (<b>AII</b>).</li><li>Genotypic drug resistance testing should be performed before initiation of ART to guide the selection of the regimen (<b>AII</b>).<ul style="list-style-type: none"><li>ART can be initiated before drug resistance test results are available. Because resistance to pharmacokinetically enhanced protease inhibitors (PIs) emerges slowly and clinically significant transmitted resistance to PIs is uncommon, ritonavir-boosted darunavir (DRV/r) and tenofovir disoproxil fumarate/emtricitabine (TDF/FTC) is a recommended regimen in this setting (<b>AIII</b>). For similar reasons, dolutegravir (DTG) plus TDF/FTC is also a reasonable option although data regarding transmission of integrase strand transfer inhibitor (INSTI)-resistant HIV and the efficacy of this regimen in early HIV infection is limited (<b>AIII</b>).</li></ul></li><li>When results of drug resistance testing are available, the treatment regimen can be modified if warranted (<b>AII</b>). In patients without transmitted drug resistant virus, therapy should be initiated with one of the combination regimens that is recommended for patients with chronic HIV-1 infection (see <a href="#">What to Start</a>) (<b>AIII</b>).</li><li>Patients starting ART should be willing and able to commit to treatment and should understand the importance of adherence (<b>AIII</b>). Patients may choose to postpone therapy, and providers, on a case-by-case basis, may recommend that patients defer therapy because of clinical and/or psychosocial factors.</li></ul>
<b>Rating of Recommendations:</b> A = Strong; B = Moderate; C = Optional
<b>Rating of Evidence:</b> I = Data from randomized controlled trials; II = Data from well-designed nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion

<sup>a</sup> Early infection represents either acute or recent infection.

**Definitions:** Acute HIV-1 infection is the phase of HIV-1 disease immediately after infection that is characterized by an initial burst of viremia; although anti-HIV-1 antibodies are undetectable, HIV-1 RNA or p24 antigen are present. Recent infection generally is considered the phase up to 6 months after infection during which anti-HIV-1 antibodies are detectable. Throughout this section, the term “early HIV-1 infection” is used to refer to either acute or recent HIV-1 infection.

An estimated 40% to 90% of patients with acute HIV-1 infection will experience symptoms of acute retroviral syndrome, such as fever, lymphadenopathy, pharyngitis, skin rash, myalgia, arthralgia, and other symptoms.<sup>1-6</sup> However, because the self-limiting symptoms are similar to those of many other viral infections, such as influenza and infectious mononucleosis, primary care clinicians often do not recognize acute HIV-1 infection. Acute infection can also be asymptomatic. [Table 11](#) provides practitioners with guidance to recognize, diagnose, and manage acute HIV-1 infection.

### Diagnosing Acute HIV Infection

Health care providers should maintain a high level of suspicion of acute HIV-1 infection in patients who have a compatible clinical syndrome—especially in those who report recent high-risk behavior (see [Table 11](#)).<sup>7</sup> Patients may not always disclose or admit to high-risk behaviors or perceive that their behaviors put them at risk for HIV-1 acquisition. Thus, even in the absence of reported high-risk behaviors, signs and symptoms consistent with acute retroviral syndrome should motivate practitioners to consider a diagnosis of acute HIV-1 infection.

Acute HIV-1 infection is usually defined as detectable HIV-1 RNA or p24 antigen in serum or plasma in the setting of a negative or indeterminate HIV-1 antibody test result.<sup>7,8</sup> Combination immunoassays that detect



HIV-1 and HIV-2 antibodies and HIV-1 p24 antigen are now approved by the Food and Drug Administration, and the most recent Centers for Disease Control and Prevention testing algorithm recommends them as the preferred assays to use for HIV screening, including for possible acute HIV-1 infection. Specimens that are reactive on an initial antigen/antibody (Ag/Ab) assay should be tested with an immunoassay that differentiates HIV-1 from HIV-2 antibodies.<sup>9</sup> Specimens that are reactive on the initial assay and have either negative or indeterminate antibody differentiation test results should be tested for quantitative or qualitative HIV-1 RNA; a negative HIV-1 RNA test result indicates that the original Ag/Ab test result was a false positive. Detection of HIV-1 RNA in this setting indicates that acute HIV-1 infection is highly likely<sup>9</sup> (see Treatment for Early HIV-1 Infection). HIV-1 infection should be confirmed by subsequent testing to document HIV antibody seroconversion.

Some health care facilities may still be following HIV testing algorithms that recommend initial testing with an assay that only tests for anti-HIV antibodies. In such settings, when acute HIV-1 infection is suspected in a patient with a negative or indeterminate HIV antibody test result, a quantitative or qualitative HIV-1 RNA test should be performed. A negative or indeterminate HIV antibody test result and a positive HIV-1 RNA test result indicate that acute HIV-1 infection is highly likely. Providers should be aware that a low-positive quantitative HIV-1 RNA level (e.g., <10,000 copies/mL) may represent a false-positive result because HIV-1 RNA levels in acute infection are generally very high (e.g., >100,000 copies/mL).<sup>5,6</sup> Therefore, when a low-positive quantitative HIV-1 RNA test result is obtained, the HIV-1 RNA test should be repeated using a different specimen from the same patient.<sup>6</sup> The diagnosis of HIV-1 infection should be confirmed by subsequent documentation of HIV antibody seroconversion (see [Table 11](#)).

### ***Treating Early HIV-1 Infection***

Clinical trial data regarding the treatment of early HIV-1 infection are limited. Many individuals who enrolled in studies to assess the role of ART in early HIV-1 infection were identified as trial participants because they presented with signs or symptoms of acute infection. With the introduction of HIV screening tests that include assays for HIV-1 RNA or p24 antigen and wider HIV screening in health care settings—particularly HIV testing associated with broader use of pre-exposure prophylaxis (PrEP) by individuals at higher risk for HIV—the number of asymptomatic patients identified with early infection may increase. The initial burst of high level viremia in infected individuals usually declines shortly after acute infection (e.g., within 2 months). However, there is a rationale for treatment during recent infection (e.g., 2–6 months after infection) because during the transition to chronic infection, the immune system may not yet have maximally contained viral replication in the lymphoid tissue.<sup>10</sup> Several trials have addressed the question of the long-term benefit of potent treatment regimens initiated during early HIV-1 infection. The potential benefits and risks of treating early HIV-1 infection are discussed below.

### **Potential Benefits of Treatment During Early HIV-1 Infection**

Preliminary data indicate that treatment of early HIV-1 infection with ART improves laboratory markers of disease progression.<sup>11–15</sup> The data, though limited, indicate that treatment of early HIV-1 infection may also reduce the severity of acute disease, lower the viral set point,<sup>16–18</sup> reduce the size of the viral reservoir,<sup>19</sup> delay disease progression, enhance CD4 T lymphocyte (CD4) cell recovery,<sup>20</sup> and decrease the rate of viral mutation by suppressing viral replication and preserving immune function.<sup>21</sup> Because early HIV-1 infection is often associated with high viral loads and increased infectiousness,<sup>22</sup> and ART use by HIV-1-infected individuals reduces transmission to uninfected sexual partners,<sup>23</sup> treatment during early HIV-1 infection is expected to substantially reduce the risk of HIV-1 transmission. In addition, although data are limited and the clinical relevance unclear, initiating ART during early HIV-1 infection may preserve mucosal Th17 cell function<sup>24</sup> and mitigate the profound loss of gastrointestinal lymphoid tissue that occurs during the first weeks of infection.<sup>25,26</sup> Many of the potential benefits described above may be more likely to occur with treatment of acute infection, but they also may occur if treatment is initiated during recent HIV-1 infection.

The START Trial enrolled HIV-infected patients with CD4 counts >500 cells/mm<sup>3</sup> and randomized them to

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either start ART immediately or defer ART until their CD4 counts fell below 350 cells/mm<sup>3</sup> or an AIDS event occurred. The study demonstrated that immediate treatment resulted in a decrease in the combined endpoint of AIDS-defining illnesses, serious non-AIDS events, or death.<sup>27</sup> Similarly, TEMPRANO demonstrated decreased risk of death or severe HIV-related illness among HIV-infected patients who initiated ART with baseline CD4 counts >500 cells/mm<sup>3</sup>.<sup>28</sup> The results from these studies strengthen the evidence for the Panel on Antiretroviral Guidelines for Adults and Adolescents (the Panel)'s recommendation for ART initiation in all patients regardless of CD4 cell count (**AI**) (see [Initiation of Antiretroviral Therapy](#) section). Although neither trial collected specific information on patients with early infection, the strength of the overall results of the two studies and the evidence from other studies described above strongly suggest that, whenever possible, patients should begin ART upon diagnosis of early infection.

### **Considerations When Treating Early HIV-1 Infection**

As with chronic infection, patients with early HIV-1 infection must be willing and able to commit to treatment. On a case-by-case basis, providers may recommend that patients defer therapy for clinical and/or psychosocial reasons. If treatment during early infection is deferred, patients should be maintained in care and every effort should be made to initiate therapy as soon as they are ready.

### ***Treating Early HIV-1 Infection During Pregnancy***

Because early HIV-1 infection, especially in the setting of high level viremia, is associated with a high risk of perinatal transmission, all HIV-1-infected pregnant women should start ART as soon as possible to prevent perinatal transmission of HIV-1.<sup>29</sup>

### **Treatment Regimen for Early HIV-1 Infection**

Data from the United States and Europe demonstrate that transmitted virus may be resistant to at least one antiretroviral drug in up to 16% of patients.<sup>30,31</sup> In one study, 21% of isolates from patients with acute HIV-1 infection demonstrated resistance to at least 1 drug.<sup>32</sup> Therefore, before initiating ART in a person with early HIV-1 infection, genotypic antiretroviral (ARV) drug resistance testing should be performed to guide selection of an ARV regimen (**AII**). However, treatment initiation should not be delayed pending resistance testing results. Once results are available, the treatment regimen can be modified if warranted (**AII**).

As during chronic infection, the goal of therapy during early HIV-1 infection is to suppress plasma HIV-1 RNA to undetectable levels (**AIII**). ART should be initiated with one of the combination regimens recommended for patients with chronic infection (**AIII**) (see [What to Start](#)). If available, the results of ARV drug resistance testing or the ARV resistance pattern of the source person's virus should be used to guide selection of the ARV regimen. If therapy is started before the results of drug resistance testing are available, a pharmacologically boosted protease inhibitor (PI)-based regimen should be used (darunavir/ritonavir [**DRV/r**] is recommended) because resistance to PIs emerges slowly and clinically significant transmitted resistance to PIs is uncommon (**AIII**). For similar reasons, dolutegravir (DTG) plus tenofovir disoproxil fumarate/emtricitabine (TDF/FTC) is a reasonable treatment option, although data regarding transmission of INSTI-resistant HIV and the efficacy of DTG plus TDF/FTC in patients with acute/early infection are limited (**AIII**). DTG/abacavir (ABC)/lamivudine (3TC) is not recommended for empiric treatment of acute infection unless the patient is known to be HLA-B\*5701 negative, information that is seldom available when patients with acute infection present for care.

Given the increasing use of daily TDF/FTC for PrEP in HIV-negative individuals,<sup>33-35</sup> early infection may be diagnosed in some patients taking TDF/FTC for PrEP. In this setting, resistance testing should be performed; however, as described above, use of a pharmacologically boosted PI (**DRV/r**) and TDF/FTC or DTG and TDF/FTC remain reasonable treatment options pending resistance testing results (see [What to Start](#)).

### **Patient Follow-Up**

Testing for plasma HIV-1 RNA levels, CD4 cell counts, and toxicity monitoring should be performed as

described in [Laboratory Testing for Initial Assessment and Monitoring While on Antiretroviral Therapy](#) (e.g., HIV-1 RNA at initiation of therapy, after 2 to 8 weeks, then every 4 to 8 weeks until viral suppression, and thereafter, every 3 to 4 months) (**AII**).

### Duration of Therapy for Early HIV-1 Infection

Once ART is initiated in patients with early HIV infection, therapy should be continued indefinitely as in guidelines for patients with chronic infection. Recent studies of early HIV-1 infection have shown some benefits of starting and then stopping treatment as a potential therapeutic strategy.<sup>16-18</sup> However, a large randomized controlled trial of patients with chronic HIV-1 infection found that treatment interruption was harmful in terms of increased risk of AIDS and non-AIDS events,<sup>36</sup> and that the strategy was associated with increased markers of inflammation, immune activation, and coagulation.<sup>37</sup> For these reasons and the potential benefit of ART in reducing the risk of HIV-1 transmission, the Panel recommends indefinite continuation of ART in patients treated for early HIV-1 infection (**AIII**).

**Table 11. Identifying, Diagnosing, and Managing Acute and Recent HIV-1 Infection**

#### Suspicion of Acute HIV-1 Infection:

- Acute HIV-1 infection should be considered in individuals with signs or symptoms described below and recent (within 2 to 6 weeks) high risk of exposure to HIV-1.<sup>a</sup>
- Signs, symptoms, or laboratory findings of acute HIV-1 infection may include but are not limited to one or more of the following: fever, lymphadenopathy, skin rash, myalgia, arthralgia, headache, diarrhea, oral ulcers, leucopenia, thrombocytopenia, transaminase elevation.
- High-risk exposures include sexual contact with an HIV-1-infected person or a person at risk of HIV-1 infection, sharing of injection drug use paraphernalia, or any exposure in which an individual's mucous membranes or breaks in the skin come in contact with bodily fluid potentially infected with HIV.
- **Differential diagnosis:** The differential diagnosis of patients presenting with HIV-1 infection may include but is not limited to viral illnesses such as Epstein-Barr virus (EBV) and non-EBV (e.g., cytomegalovirus) infectious mononucleosis syndromes, influenza, viral hepatitis, streptococcal infection, or syphilis.

#### Evaluation/Diagnosis of Acute HIV-1 Infection:

- Acute HIV-1 infection is defined as detectable HIV-1 RNA or p24 antigen (the antigen used in currently available HIV antigen/antibody [Ag/Ab] combination assays) in the setting of a negative or indeterminate HIV-1 antibody test result.
- A reactive HIV antibody test result or Ag/Ab combination test result must be followed by supplemental confirmatory testing.
- A negative or indeterminate HIV-1 antibody test result in a person with a reactive Ag/Ab test result or in whom acute HIV-1 infection is suspected requires plasma HIV-1 RNA testing to diagnose acute HIV-1 infection.
- A positive result on a quantitative or qualitative plasma HIV-1 RNA test in the setting of a negative or indeterminate antibody test result indicates that acute HIV-1 infection is highly likely.

#### ART After Diagnosis of Early HIV-1 Infection:

- ART is recommended for all HIV-infected individuals (**AI**), and should be offered to all patients with early HIV-1 infection.
- All pregnant women with early HIV-1 infection should begin ART as soon as possible for their health and to prevent perinatal transmission of HIV-1.
- Genotypic drug resistance testing should be performed before initiation of ART to guide the selection of the regimen (**AII**).
- If ART is initiated before drug resistance test results are available, a pharmacologically boosted PI-based regimen is recommended because resistance to PIs emerges slowly and clinically significant transmitted resistance to PIs is uncommon. DRV/r plus TDF/FTC is a recommended regimen in this setting (**AIII**). For similar reasons, DTG plus TDF/FTC is a reasonable option although the data regarding transmission of INSTI-resistant HIV and the efficacy of this regimen in early HIV infection are limited (**AIII**).
- When results of drug resistance testing are available, the treatment regimen can be modified if warranted (**AII**). In patients without transmitted drug-resistant virus, ART should be initiated with one of the combination regimens that is recommended for patients with chronic HIV-1 infection (see [What to Start](#)) (**AIII**).
- Once initiated, the goal of ART should be sustained plasma virologic suppression; ART should be continued indefinitely (**AIII**).

<sup>a</sup> In some settings, behaviors that increase the risk of HIV-1 infection may not be recognized or perceived as risky by the health care provider or the patient or both. Thus, even in the absence of reported high-risk behaviors, symptoms and signs consistent with acute retroviral syndrome should motivate practitioners to consider a diagnosis of acute HIV-1 infection.

**Key to Acronyms:** ART = antiretroviral therapy; ARV = antiretroviral; DRV/r = darunavir/ritonavir; **DTG = dolutegravir**; INSTI = integrase strand transfer inhibitor; PI = protease inhibitor; TDF/FTC = tenofovir disoproxil fumarate/emtricitabine

## References

1. Tindall B, Cooper DA. Primary HIV infection: host responses and intervention strategies. *AIDS*. Jan 1991;5(1):1-14. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=1812848](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=1812848).
2. Niu MT, Stein DS, Schnittman SM. Primary human immunodeficiency virus type 1 infection: review of pathogenesis and early treatment intervention in humans and animal retrovirus infections. *J Infect Dis*. Dec 1993;168(6):1490-1501. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=8245534](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=8245534).
3. Kinloch-de Loes S, de Saussure P, Saurat JH, Stalder H, Hirschel B, Perrin LH. Symptomatic primary infection due to human immunodeficiency virus type 1: review of 31 cases. *Clin Infect Dis*. Jul 1993;17(1):59-65. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=8353247](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=8353247).
4. Schacker T, Collier AC, Hughes J, Shea T, Corey L. Clinical and epidemiologic features of primary HIV infection. *Ann Intern Med*. Aug 15 1996;125(4):257-264. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=8678387](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=8678387).
5. Daar ES, Little S, Pitt J, et al. Diagnosis of primary HIV-1 infection. Los Angeles County Primary HIV Infection Recruitment Network. *Ann Intern Med*. Jan 2 2001;134(1):25-29. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=11187417](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11187417).
6. Hecht FM, Busch MP, Rawal B, et al. Use of laboratory tests and clinical symptoms for identification of primary HIV infection. *AIDS*. May 24 2002;16(8):1119-1129. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=12004270](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=12004270).
7. Branson BM, Handsfield HH, Lampe MA, et al. Revised recommendations for HIV testing of adults, adolescents, and pregnant women in health-care settings. *MMWR Recomm Rep*. Sep 22 2006;55(RR-14):1-17. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=16988643](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16988643).
8. Pilcher CD, Christopoulos KA, Golden M. Public health rationale for rapid nucleic acid or p24 antigen tests for HIV. *J Infect Dis*. Apr 15 2010;201 Suppl 1:S7-15. Available at <http://www.ncbi.nlm.nih.gov/pubmed/20225950>.
9. Centers for Disease Control and Prevention and Association of Public Health Laboratories. Laboratory Testing for the Diagnosis of HIV Infection: Updated Recommendations. 2014. Available at <http://stacks.cdc.gov/view/cdc/23447>. Accessed January 12, 2016.
10. Pantaleo G, Cohen OJ, Schacker T, et al. Evolutionary pattern of human immunodeficiency virus (HIV) replication and distribution in lymph nodes following primary infection: implications for antiviral therapy. *Nat Med*. Mar 1998;4(3):341-345. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=9500610](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=9500610).
11. Hoen B, Dumon B, Harzic M, et al. Highly active antiretroviral treatment initiated early in the course of symptomatic primary HIV-1 infection: results of the ANRS 053 trial. *J Infect Dis*. Oct 1999;180(4):1342-1346. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=10479169](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=10479169).
12. Lafeuillade A, Poggi C, Tamalet C, Profizi N, Tourres C, Costes O. Effects of a combination of zidovudine, didanosine, and lamivudine on primary human immunodeficiency virus type 1 infection. *J Infect Dis*. May 1997;175(5):1051-1055. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=9129065](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=9129065).
13. Lillo FB, Ciuffreda D, Veglia F, et al. Viral load and burden modification following early antiretroviral therapy of primary HIV-1 infection. *AIDS*. May 7 1999;13(7):791-796. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=10357377](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=10357377).
14. Malhotra U, Berrey MM, Huang Y, et al. Effect of combination antiretroviral therapy on T-cell immunity in acute human immunodeficiency virus type 1 infection. *J Infect Dis*. Jan 2000;181(1):121-131. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=10608758](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=10608758).
15. Smith DE, Walker BD, Cooper DA, Rosenberg ES, Kaldor JM. Is antiretroviral treatment of primary HIV infection clinically justified on the basis of current evidence? *AIDS*. Mar 26 2004;18(5):709-718. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=15075505](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15075505).



16. Hogan CM, Degruittola V, Sun X, et al. The setpoint study (ACTG A5217): effect of immediate versus deferred antiretroviral therapy on virologic set point in recently HIV-1-infected individuals. *J Infect Dis*. Jan 1 2012;205(1):87-96. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22180621>.
17. Grijzen ML, Steingrover R, Wit FW, et al. No treatment versus 24 or 60 weeks of antiretroviral treatment during primary HIV infection: the randomized Primo-SHM trial. *PLoS Med*. 2012;9(3):e1001196. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22479156>.
18. Hamlyn E, Ewings FM, Porter K, et al. Plasma HIV viral rebound following protocol-indicated cessation of ART commenced in primary and chronic HIV infection. *PLoS One*. 2012;7(8):e43754. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22952756>.
19. Strain MC, Little SJ, Daar ES, et al. Effect of treatment, during primary infection, on establishment and clearance of cellular reservoirs of HIV-1. *J Infect Dis*. May 1 2005;191(9):1410-1418. Available at <http://www.ncbi.nlm.nih.gov/pubmed/15809898>.
20. SPARTAC Trial Investigators, Fidler S, Porter K, et al. Short-course antiretroviral therapy in primary HIV infection. *N Engl J Med*. Jan 17 2013;368(3):207-217. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23323897>.
21. Rosenberg ES, Altfeld M, Poon SH, et al. Immune control of HIV-1 after early treatment of acute infection. *Nature*. Sep 28 2000;407(6803):523-526. Available at <http://www.ncbi.nlm.nih.gov/pubmed/11029005>.
22. Wawer MJ, Gray RH, Sewankambo NK, et al. Rates of HIV-1 transmission per coital act, by stage of HIV-1 infection, in Rakai, Uganda. *J Infect Dis*. May 1 2005;191(9):1403-1409. Available at <http://www.ncbi.nlm.nih.gov/pubmed/15809897>.
23. Cohen MS, Chen YQ, McCauley M, et al. Prevention of HIV-1 infection with early antiretroviral therapy. *N Engl J Med*. Aug 11 2011;365(6):493-505. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=21767103](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=21767103).
24. Schuetz A, Deleage C, Sereti I, et al. Initiation of ART during early acute HIV infection preserves mucosal Th17 function and reverses HIV-related immune activation. *PLoS Pathog*. Dec 2014;10(12):e1004543. Available at <http://www.ncbi.nlm.nih.gov/pubmed/25503054>.
25. Mehandru S, Poles MA, Tenner-Racz K, et al. Primary HIV-1 infection is associated with preferential depletion of CD4+ T lymphocytes from effector sites in the gastrointestinal tract. *J Exp Med*. Sep 20 2004;200(6):761-770. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=15365095](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15365095).
26. Guadalupe M, Reay E, Sankaran S, et al. Severe CD4+ T-cell depletion in gut lymphoid tissue during primary human immunodeficiency virus type 1 infection and substantial delay in restoration following highly active antiretroviral therapy. *J Virol*. Nov 2003;77(21):11708-11717. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=14557656](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=14557656).
27. INSIGHT START Study Group. Initiation of antiretroviral therapy in early asymptomatic HIV infection. *N Engl J Med*. Jul 20 2015. Available at <http://www.ncbi.nlm.nih.gov/pubmed/26192873>.
28. TEMPRANO ANRS Study Group, Danel C, Moh R, et al. A trial of early antiretrovirals and Isoniazid preventive therapy in Africa. *N Engl J Med*. Aug 27 2015;373(9):808-822. Available at <http://www.ncbi.nlm.nih.gov/pubmed/26193126>.
29. Panel on Treatment of HIV-Infected Pregnant Women and Prevention of Perinatal Transmission. Recommendations for use of antiretroviral drugs in pregnant HIV-1-infected women for maternal health and interventions to reduce perinatal HIV transmission in the United States. 2014. Available at <http://aidsinfo.nih.gov/contentfiles/PerinatalGL.pdf>. Accessed March 19, 2015.
30. Kim D, Ziebell R, Saduvala N, et al. Trend in transmitted HIV-1 ARV drug Resistance-associated mutations: 10 HIV surveillance areas, U.S., 2007–2010. Paper presented at: 20th Conference on Retroviruses and Opportunistic Infections. 2013. Atlanta, Georgia.
31. Hofstra LM, Sauvageot N, Albert J, et al. Transmission of HIV drug resistance and the predicted effect on current first-line regimens in Europe. *Clin Infect Dis*. Nov 29 2015. Available at <http://www.ncbi.nlm.nih.gov/pubmed/26620652>.
32. Yanik EL, Napravnik S, Hurt CB, et al. Prevalence of transmitted antiretroviral drug resistance differs between acutely and chronically HIV-infected patients. *J Acquir Immune Defic Syndr*. Oct 1 2012;61(2):258-262. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22692092>.
33. Grant RM, Lama JR, Anderson PL, et al. Preexposure chemoprophylaxis for HIV prevention in men who have sex with men. *N Engl J Med*. Dec 30 2010;363(27):2587-2599. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21091279>.
34. Baeten JM, Donnell D, Ndase P, et al. Antiretroviral prophylaxis for HIV prevention in heterosexual men and women. *N Engl J Med*. Aug 2 2012;367(5):399-410. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22784037>.



35. Thigpen MC, Kebaabetswe PM, Paxton LA, et al. Antiretroviral preexposure prophylaxis for heterosexual HIV transmission in Botswana. *N Engl J Med*. Aug 2 2012;367(5):423-434. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22784038>.
36. Strategies for Management of Antiretroviral Therapy Study G, El-Sadr WM, Lundgren J, et al. CD4+ count-guided interruption of antiretroviral treatment. *N Engl J Med*. Nov 30 2006;355(22):2283-2296. Available at <http://www.ncbi.nlm.nih.gov/pubmed/17135583>.
37. Kuller LH, Tracy R, Belloso W, et al. Inflammatory and coagulation biomarkers and mortality in patients with HIV infection. *PLoS Med*. Oct 21 2008;5(10):e203. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18942885](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18942885).

### Key Summary and Panel's Recommendations

- HIV-infected adolescents largely belong to two distinct groups—those who acquired HIV in infancy, and are heavily antiretroviral therapy (ART)-experienced, and those who acquired HIV more recently during their teens.
- ART is recommended for all HIV-infected individuals **(AI)** to reduce morbidity and mortality. Thus, ART is also recommended for ART-naive adolescents. However, before initiation of therapy, adolescents' readiness and ability to adhere to therapy within their psychosocial context need to be carefully considered as part of therapeutic decision making **(AIII)**.
- Once ART is initiated, appropriate support is essential to reduce potential barriers to adherence and maximize the success in achieving sustained viral suppression **(AII)**.
- The adolescent sexual maturity rating can be helpful to guide regimen selection for initiation of or changes in ART as recommended by either these Adult and Adolescent ART Guidelines or the Pediatric ART Guidelines. These Adult/Adolescent Guidelines are more appropriate for postpubertal adolescents (i.e., sexual maturity rating IV or V) **(AIII)**.
- Pediatric and adolescent care providers should prepare adolescents for the transition into adult care settings. Adult providers should be sensitive to the challenges associated with such transitions, consulting and collaborating with adolescent HIV care providers to insure adolescents' successful transition and continued engagement in care **(AIII)**.

**Rating of Recommendations:** A = Strong; B = Moderate; C = Optional

**Rating of Evidence:** I = Data from randomized controlled trials; II = Data from well-designed nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion

Older children and adolescents now make up the largest percentage of HIV-infected children cared for at pediatric HIV clinics in the United States. The Centers for Disease Control and Prevention (CDC) estimates that 26% of the approximately 50,000 new HIV infections diagnosed in 2010 were among youth 13 to 24 years of age. In this age group, 57% of the infections were among young black/African Americans and 75% among young **gay and bisexual** men who have sex with men (MSM).<sup>1</sup> Among youth living with HIV infection in 2010, CDC estimates that almost 60% had undiagnosed infections and were unaware they were HIV-infected.<sup>2</sup> Trends in HIV/AIDS prevalence indicate that the disproportionate burden of AIDS among racial minorities is even greater among minority youth 13 to 24 years of age (64% to 66% of cases) than among those older than 24 years (48% of cases).<sup>3</sup> Furthermore, trends for all HIV diagnoses among adolescents and young adults in 46 states and 5 U.S. dependent areas from 2007 to 2010 decreased or remained stable for all transmission categories except among young MSM. HIV-infected adolescents represent a heterogeneous group in terms of socio-demographics, mode of HIV infection, sexual and substance abuse history, clinical and immunologic status, psychosocial development, and readiness to adhere to medications. Many of these factors may influence decisions concerning when to start antiretroviral therapy (ART) and what antiretroviral (ARV) medications to use.

Most adolescents who acquire HIV are infected through sex. Many of them are recently infected and unaware of their HIV infection status. Thus, many are in an early stage of HIV infection, which makes them ideal candidates for early interventions, such as prevention counseling, linkage to and engagement in care, **and initiation of ART**.<sup>4</sup> High grade viremia was reported in a cohort of youth identified as HIV-infected by adolescent HIV specialty clinics in 15 major metropolitan U.S. cities. The mean HIV viral load for the cohort was 94,398 copies/ml; 30% of the youth were not successfully linked to care.<sup>5</sup> A study among HIV-infected adolescents and young adults presenting for care identified primary genotypic resistance mutations to ARV medications in up to 18% of the evaluable sample of recently infected youth, as determined by the detuned antibody testing assay strategy that defined recent infection as occurring within 180 days of testing.<sup>6</sup> Substantial multiclass resistance was noted in a cohort of non-perinatally infected, treatment-naive youth

who were screened for an ARV treatment trial.<sup>7</sup> As these youth were naive to all ART, this reflects transmission of resistant virus. This transmission dynamic reflects that a substantial proportion of youth's sexual partners are likely older and may be more ART experienced; thus, using baseline resistance testing to guide initial therapy in recently infected youth naive to ART is imperative.

A limited but increasing number of HIV-infected adolescents are long-term survivors of HIV infection acquired perinatally or in infancy through blood products. These adolescents are usually heavily ART experienced and may have a unique clinical course that differs from that of adolescents infected later in life.<sup>8</sup> Adolescents infected perinatally or in infancy were often started on ART early in life with mono or dual therapy regimens resulting in incomplete viral suppression and emergence of viral resistance. If these heavily ART-experienced adolescents harbor resistant virus, optimal ARV regimens should be selected on the basis of the same guiding principles used for heavily ART-experienced adults (see [Virologic Failure section](#)).

Adolescents are developmentally at a difficult crossroad. Their needs for autonomy and independence and their evolving decisional capacity intersect and compete with their concrete thinking processes, risk-taking behaviors, preoccupation with self-image, and need to fit in with their peers. This makes it challenging to attract and sustain adolescents' focus on maintaining their health, particularly for those with chronic illnesses. These challenges are not specific to any particular transmission mode or stage of disease. Thus, irrespective of disease duration or mode of HIV transmission, every effort must be made to engage and retain adolescents in care so they can improve and maintain their health for the long term. Given challenges with youth remaining in care and achieving long-term viral suppression,<sup>9</sup> additional considerations may be given to more intensive case management approaches.<sup>10,11</sup> Adolescents may seek care in several settings including pediatric-focused HIV clinics, adolescent/young adult clinics, and adult-focused clinics.<sup>12</sup> Where youth services are available, they may be helpful to consider as one approach to enhancing HIV care engagement and retention among adolescents.<sup>13</sup> Regardless of the setting, expertise in caring for adolescents is critical to creating a supportive environment for engaging youth in care.<sup>12,14</sup>

### ***Antiretroviral Therapy Considerations in Adolescents***

The results from the START and TEMPRANO trials that favor initiating ART in all individuals who are able and willing to commit to treatment, and can understand the benefits and risks of therapy and the importance of excellent adherence, are discussed elsewhere in these guidelines (see [Initiation of Antiretroviral Therapy](#)). Neither of these trials included adolescents; however, recommendations based on these trials have been extrapolated to adolescents based on the expectation that they will derive benefits from early ART similar to those observed in adults. Given the psychosocial turmoil that may occur frequently in the lives of HIV-infected American youth, their ability to adhere to therapy needs to be carefully considered as part of therapeutic decision making concerning the risks and benefits of starting treatment. Once ART is initiated, appropriate support is essential to reduce potential barriers to adherence and maximize the success in achieving sustained viral suppression.

The adolescent sexual maturity rating (SMR) (also known as Tanner stage) can be helpful when ART initiation is being considered for this population (see [SMR table](#)). Adult guidelines for ART initiation or regimen changes (see Adult Guidelines, [What to Start](#)) are usually appropriate for postpubertal adolescents (SMR IV or V) because the clinical course of HIV infection in postpubertal adolescents who were infected sexually or through injection drug use during adolescence is more similar to that in adults than that in children. Adult guidelines can also be useful for postpubertal youth who were perinatally infected and whose long-term HIV infection has not affected their sexual maturity (SMR IV or V). Pediatric guidelines for ART may be more appropriate for adolescents infected with HIV during their teen years (e.g., through sex), but who are sexually immature (SMR III or less) and for perinatally infected adolescents with stunted sexual maturation (i.e., delayed puberty) from long-standing HIV infection or other co-morbidities (SMR III or less) (see [What to Start](#) in the [Guidelines for the Use of Antiretroviral Agents in Pediatric HIV Infection](#)).

Perinatally infected, postpubertal youth often have treatment challenges associated with the long-term use of ART that mirror those of ART-experienced adults, such as extensive resistance, complex regimens, and adverse drug effects (see also [Virologic Failure](#), [Poor CD4 Recovery](#), [Regimen Switching in the Setting of Virologic Suppression](#), and [Adverse Effects of Antiretroviral Agents](#)). Perinatally infected postpubertal adolescents may also have comorbid cognitive impairments that compound adherence challenges common among youth.<sup>15</sup>

Dosage of ARV drugs should be prescribed according to the SMR and not solely on the basis of age.<sup>16,17</sup>

Adolescents in early puberty (i.e., [SMR I-III](#)) should be administered doses on pediatric schedules, whereas those in late puberty (i.e., [SMR IV-V](#)) should follow adult dosing schedules. However, SMR stage and age are not necessarily directly predictive of drug pharmacokinetics. Because puberty may be delayed in children who were infected with HIV perinatally,<sup>18</sup> continued use of pediatric doses in puberty-delayed adolescents can result in medication doses that are higher than the usual adult doses. Because data are not available to predict optimal medication doses for each ARV medication for this group of children, issues such as toxicity, pill or liquid volume burden, adherence, and virologic and immunologic parameters should be considered in determining when to transition youth from pediatric to adult doses. Youth who are in their growth spurt period (i.e., Tanner Stage III in females and Tanner Stage IV in males) following adult or pediatric dosing guidelines and adolescents who have transitioned from pediatric to adult doses should be closely monitored for medication efficacy and toxicity. Therapeutic drug monitoring can be considered in each of these selected circumstances to help guide therapy decisions. Pharmacokinetic studies of drugs in youth are needed to better define appropriate dosing. For a more detailed discussion, see [Guidelines for the Use of Antiretroviral Agents in Pediatric HIV Infection](#).<sup>19</sup>

### ***Adherence Concerns in Adolescents***

HIV-infected adolescents are especially vulnerable to specific adherence problems because of their psychosocial and cognitive developmental trajectory. Comprehensive systems of care are required to serve both the medical and psychosocial needs of HIV-infected adolescents, who frequently lack both health insurance and experience with health care systems. Studies in adolescents infected in their teen years and in adolescents infected through perinatal transmission demonstrate that many adolescents in both groups face numerous barriers to adherence.<sup>20-22</sup> Compared with adults, these youth have lower rates of viral suppression and higher rates of virologic rebound and loss to follow up.<sup>23</sup> Reasons that HIV-infected adolescents often have difficulty adhering to medical regimens include the following:

- Denial and fear of their HIV infection;
- Misinformation;
- Distrust of the medical establishment;
- Fear of ART and lack of confidence in the effectiveness of medications;
- Low self-esteem;
- Unstructured and chaotic lifestyles;
- Mood disorders and other mental illness;
- Lack of familial and social support;
- Lack of or inconsistent access to care or health insurance; and
- Risk of inadvertent disclosure of their HIV infection if parental health insurance is used.

Clinicians selecting treatment regimens for adolescents must balance the goal of prescribing a maximally potent ART regimen with realistic assessment of existing and potential support systems to facilitate adherence. Adolescents benefit from reminder systems (e.g., apps, beepers, timers, and pill boxes) that are stylish and/or inconspicuous.<sup>24</sup> In a randomized controlled study among non-adherent youth 15 to 24 years of age, youth who

received cell phone medication reminders demonstrated significantly better adherence and lower viral loads than youth who did not receive the reminder calls.<sup>25</sup> It is important to make medication adherence as user friendly and the least stigmatizing as possible for the older child or adolescent. The concrete thought processes of adolescents make it difficult for them to take medications when they are asymptomatic, particularly if the medications have side effects. Adherence to complex regimens is particularly challenging at a time of life when adolescents do not want to be different from their peers.<sup>26-28</sup> Directly observed therapy may be considered for some HIV-infected adolescents such as those with mental illness.<sup>29-33</sup>

### ***Difficult Adherence Problems***

Because adolescence is characterized by rapid changes in physical maturation, cognitive processes, and life style, predicting long-term adherence in an adolescent can be very challenging. The ability of youth to adhere to therapy needs to be considered as part of therapeutic decision making concerning the risks and benefits of starting treatment. Erratic adherence may result in the loss of future regimens because of the development of resistance mutations. Clinicians who care for HIV-infected adolescents frequently manage youth who, although needing therapy, pose significant concerns regarding their ability to adhere to therapy. In these cases, the following strategies can be considered:

1. A short-term deferral of treatment until adherence is more likely or while adherence-related problems are aggressively addressed;
2. An adherence testing period in which a placebo (e.g., vitamin pill) is administered; and
3. The avoidance of any regimens with low genetic resistance barriers.

Such decisions are ideally individualized to each patient and should be made carefully in context with the individual's clinical status. For a more detailed discussion on specific therapy and adherence issues for HIV-infected adolescents, see the [Adherence to ART](#) section of these guidelines and the [Guidelines for Use of Antiretroviral Agents in Pediatric HIV Infection](#).<sup>19</sup>

### ***Special Considerations in Adolescents***

All adolescents should be screened for sexually transmitted diseases (STDs), in particular human papilloma virus (HPV). In young MSM, screening for STDs may require sampling from several body sites because oropharyngeal, rectal, and urethral infections may be present in this population.<sup>34</sup> For a more detailed discussion on STDs, see the most recent CDC guidelines<sup>35</sup> and the adult and pediatric opportunistic infection treatment **and prevention** guidelines on HPV among HIV-infected adolescents.<sup>36,37</sup> Family planning counseling, including a discussion of the risks of perinatal transmission of HIV and methods to reduce risks, should be provided to all youth. Providing gynecologic care for HIV-infected female adolescents is especially important. Contraception, including the interaction of specific ARV drugs with hormonal contraceptives, and the potential for pregnancy also may alter choices of ART. As an example, efavirenz (EFV) should be used with caution in females of childbearing age and should only be prescribed after intensive counseling and education about the potential effects on the fetus, the need for close monitoring—including periodic pregnancy testing—and a commitment on the part of the teen to use effective contraception. For a more detailed discussion, see [HIV-Infected Women](#) and the [Perinatal Guidelines](#).<sup>38</sup>

Finally, HIV-infected transgender youth represent an important population that requires additional psychosocial and healthcare considerations. For a more detailed discussion, see [Adolescent Trials Network \(ATN\) Transgender Youth Resources](#).

### ***Transitioning Care***

Given lifelong infection with HIV and the need for treatment through several stages of growth and development, HIV care programs and providers need flexibility to appropriately transition care for HIV-infected children, adolescents, and young adults. A successful transition requires an awareness of some



fundamental differences between many adolescent and adult HIV care models. In most adolescent HIV clinics, care is more teen-centered and multidisciplinary, with primary care highly integrated into HIV care. Teen services, such as sexual and reproductive health, substance abuse treatment, mental health, treatment education, and adherence counseling are all found in one clinic setting. In contrast, some adult HIV clinics may rely more on referral of the patient to separate subspecialty care settings, such as gynecology. Transitioning the care of an emerging young adult includes considerations of areas such as medical insurance; the adolescent's degree of independence/autonomy and decisional capacity; patient confidentiality; and informed consent. Also, adult clinic settings tend to be larger and can easily intimidate younger, less motivated patients. As an additional complication to this transition, HIV-infected adolescents belong to two epidemiologically distinct subgroups with unique biomedical and psychosocial considerations and needs:

- Perinatally infected adolescents—who would likely have more disease burden history, complications, and chronicity; less functional autonomy; greater need for ART; and higher mortality risk—and
- Youth more recently infected during their adolescence—who would likely be in earlier stages of HIV infection and have higher CD4 cell counts; these adolescents would be less likely to have viral drug resistance and may benefit from simpler treatment regimen options.

To maximize the likelihood of a successful transition, interventions to facilitate transition are best implemented early on.<sup>39</sup> These interventions include the following:

- Developing an individualized transition plan to address comprehensive care needs including medical, psychosocial, and financial aspects of transitioning;
- Optimizing provider communication between adolescent and adult clinics;
- Identifying adult care providers willing to care for adolescents and young adults;
- Addressing patient and family resistance to transition of care caused by lack of information, concerns about stigma or risk of disclosure, and differences in practice styles;
- Helping youth develop life skills, including counseling them on the appropriate use of a primary care provider and how to manage appointments, the importance of prompt symptom recognition and reporting, and the importance of self-efficacy in managing medications, insurance, and assistance benefits;
- Identifying an optimal clinic model based on specific needs (i.e., simultaneous transition of mental health and/or case management versus a gradual phase-in);
- Implementing ongoing evaluation to measure the success of a selected model;
- Engaging adult and adolescent care providers in regular multidisciplinary case conferences;
- Implementing interventions that may improve outcomes, such as support groups and mental health consultation;
- Incorporating a family planning component into clinical care; and
- Educating HIV care teams and staff about transitioning.

Discussions regarding transition should begin early and before the actual transition process.<sup>40</sup> Attention to the key interventions noted above will likely improve adherence to appointments and avert the potential for a youth to fall through the cracks, as it is commonly referred to in adolescent medicine. For a more detailed discussion on specific topics on transitioning care for adolescents and young adults, see <http://www.hivguidelines.org/clinical-guidelines/adolescents/transitioning-hiv-infected-adolescents-into-adult-care/>.

## References

1. Centers for Disease Control and Prevention. Monitoring selected national HIV prevention and care objectives by using HIV surveillance data—United States and 6 U.S. dependent areas—2010. *HIV Surveillance Supplemental Report 2012;17(No. 3, part A)*. Table 5a. 2012. <http://www.cdc.gov/hiv/topics/surveillance/resources/reports/>. Accessed January

6, 2015.

2. Centers for Disease C, Prevention. Vital signs: HIV infection, testing, and risk behaviors among youths—United States. *MMWR Morb Mortal Wkly Rep*. Nov 30 2012;61(47):971-976. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23190571>.
3. Centers for Disease Control and Prevention. HIV Surveillance in Adolescents and Young Adults. 2011. Available at [http://www.cdc.gov/hiv/pdf/statistics\\_surveillance\\_Adolescents.pdf](http://www.cdc.gov/hiv/pdf/statistics_surveillance_Adolescents.pdf). Accessed January 15, 2016.
4. Philbin MM, Tanner AE, Duval A, Ellen J, Kapogiannis B, Fortenberry JD. Linking HIV-positive adolescents to care in 15 different clinics across the United States: Creating solutions to address structural barriers for linkage to care. *AIDS Care*. Jan 2014;26(1):12-19. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23777542>.
5. Ellen JM, Kapogiannis B, Fortenberry JD, et al. HIV viral load levels and CD4+ cell counts of youth in 14 cities. *AIDS*. May 15 2014;28(8):1213-1219. Available at <http://www.ncbi.nlm.nih.gov/pubmed/25028912>.
6. Viani RM, Peralta L, Aldrovandi G, et al. Prevalence of primary HIV-1 drug resistance among recently infected adolescents: a multicenter adolescent medicine trials network for HIV/AIDS interventions study. *J Infect Dis*. Dec 1 2006;194(11):1505-1509. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17083034](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17083034).
7. Agwu AL, Bethel J, Hightow-Weidman LB, et al. Substantial multiclass transmitted drug resistance and drug-relevant polymorphisms among treatment-naïve behaviorally HIV-infected youth. *AIDS Patient Care STDS*. Apr 2012;26(4):193-196. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22563607>.
8. Van Dyke RB, Patel K, Siberry GK, et al. Antiretroviral treatment of US children with perinatally acquired HIV infection: temporal changes in therapy between 1991 and 2009 and predictors of immunologic and virologic outcomes. *J Acquir Immune Defic Syndr*. Jun 1 2011;57(2):165-173. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21407086>.
9. Zanon BC, Mayer KH. The adolescent and young adult HIV cascade of care in the United States: exaggerated health disparities. *AIDS Patient Care STDS*. Mar 2014;28(3):128-135. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24601734>.
10. Hightow-Weidman LB, Smith JC, Valera E, Matthews DD, Lyons P. Keeping them in "STYLE": finding, linking, and retaining young HIV-positive black and Latino men who have sex with men in care. *AIDS Patient Care STDS*. Jan 2011;25(1):37-45. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21162690>.
11. Sitapati AM, Limneos J, Bonet-Vazquez M, Mar-Tang M, Qin H, Mathews WC. Retention: building a patient-centered medical home in HIV primary care through PUFF (Patients Unable to Follow-up Found). *J Health Care Poor Underserved*. Aug 2012;23(3 Suppl):81-95. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22864489>.
12. Tanner AE, Philbin MM, Duval A, et al. "Youth friendly" clinics: Considerations for linking and engaging HIV-infected adolescents into care. *AIDS Care*. Feb 2014;26(2):199-205. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23782040>.
13. Davila JA, Miertschin N, Sansgiry S, Schwarzwald H, Henley C, Giordano TP. Centralization of HIV services in HIV-positive African-American and Hispanic youth improves retention in care. *AIDS Care*. 2013;25(2):202-206. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22708510>.
14. New York State Department of Health AIDS Institute. *Ambulatory Care of HIV-Infected Adolescents*. 2012. Available at <http://hivguidelines.org/wp-content/uploads/2012/11/ambulatory-care-of-hiv-infected-adolescents-11-19-2012.pdf>. Accessed January 6, 2016.
15. Nichols SL, Brummel SS, Smith RA, et al. Executive Functioning in Children and Adolescents With Perinatal HIV Infection. *Pediatr Infect Dis J*. Sep 2015;34(9):969-975. Available at <http://www.ncbi.nlm.nih.gov/pubmed/26376309>.
16. Rogers A (ed). Pharmacokinetics and pharmacodynamics in adolescents. *J Adolesc Health*. 1994;15:605-678.
17. El-Sadar W, Oleske JM, Agins BD, et al. Evaluation and management of early HIV infection. Clinical Practice Guideline No. 7 (AHCPR Publication No. 94-0572). Rockville, MD: Agency for Health Care Policy and Research, Public Health Service, US Department of Health and Human Services. 1994.
18. Buchacz K, Rogol AD, Lindsey JC, et al. Delayed onset of pubertal development in children and adolescents with perinatally acquired HIV infection. *J Acquir Immune Defic Syndr*. 2003;33(1):56-65. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?db=pubmed&cmd=Retrieve&dopt=AbstractPlus&list\\_uids=12792356&query\\_hl=17&itool=pubmed\\_docsum](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?db=pubmed&cmd=Retrieve&dopt=AbstractPlus&list_uids=12792356&query_hl=17&itool=pubmed_docsum).
19. Panel on Antiretroviral Therapy and Medical Management of HIV-Infected Children. *Guidelines for the use of antiretroviral agents in pediatric HIV infection*. 2014. Available at <http://aidsinfo.nih.gov/contentfiles/lvguidelines/pediatricguidelines.pdf>. Accessed January 15, 2016.

20. Rudy BJ, Murphy DA, Harris DR, Muenz L, Ellen J, Adolescent Trials Network for HIVAI. Prevalence and interactions of patient-related risks for nonadherence to antiretroviral therapy among perinatally infected youth in the United States. *AIDS Patient Care STDS*. Feb 2010;24(2):97-104. Available at <http://www.ncbi.nlm.nih.gov/pubmed/20059354>.
21. Rudy BJ, Murphy DA, Harris DR, Muenz L, Ellen J, Adolescent Trials Network for HIVAI. Patient-related risks for nonadherence to antiretroviral therapy among HIV-infected youth in the United States: a study of prevalence and interactions. *AIDS Patient Care STDS*. Mar 2009;23(3):185-194. Available at <http://www.ncbi.nlm.nih.gov/pubmed/19866536>.
22. MacDonell K, Naar-King S, Huszti H, Belzer M. Barriers to medication adherence in behaviorally and perinatally infected youth living with HIV. *AIDS Behav*. Jan 2013;17(1):86-93. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23142855>.
23. Ryscavage P, Anderson EJ, Sutton SH, Reddy S, Taiwo B. Clinical outcomes of adolescents and young adults in adult HIV care. *J Acquir Immune Defic Syndr*. Oct 1 2011;58(2):193-197. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21826014>.
24. Lyon ME, Trexler C, Akpan-Townsend C, et al. A family group approach to increasing adherence to therapy in HIV-infected youths: results of a pilot project. *AIDS Patient Care STDS*. Jun 2003;17(6):299-308. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=12880493](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=12880493).
25. Belzer ME, Kolmodin MacDonell K, Clark LF, et al. Acceptability and Feasibility of a Cell Phone Support Intervention for Youth Living with HIV with Nonadherence to Antiretroviral Therapy. *AIDS Patient Care STDS*. Jun 2015;29(6):338-345. Available at <http://www.ncbi.nlm.nih.gov/pubmed/25928772>.
26. Brooks-Gunn J, Graber JA. Puberty as a biological and social event: implications for research on pharmacology. *J Adolesc Health*. Dec 1994;15(8):663-671. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=7696287](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=7696287).
27. Kyngas H, Hentinen M, Barlow JH. Adolescents' perceptions of physicians, nurses, parents and friends: help or hindrance in compliance with diabetes self-care? *J Adv Nurs*. Apr 1998;27(4):760-769. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=9578206](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=9578206).
28. La Greca AM. Peer influences in pediatric chronic illness: an update. *J Pediatr Psychol*. Dec 1992;17(6):775-784. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=1484338](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=1484338).
29. Murphy DA, Wilson CM, Durako SJ, Muenz LR, Belzer M. Antiretroviral medication adherence among the REACH HIV-infected adolescent cohort in the USA. *AIDS Care*. Feb 2001;13(1):27-40. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=11177463](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11177463).
30. Stenzel MS, McKenzie M, Mitty JA, Flanigan TP. Enhancing adherence to HAART: a pilot program of modified directly observed therapy. *AIDS Read*. Jun 2001;11(6):317-319, 324-328. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=11449925](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11449925).
31. Purdy JB, Freeman AF, Martin SC, et al. Virologic response using directly observed therapy in adolescents with HIV: an adherence tool. *J Assoc Nurses AIDS Care*. Mar-Apr 2008;19(2):158-165. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18328966](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18328966).
32. Garvie PA, Lawford J, Flynn PM, et al. Development of a directly observed therapy adherence intervention for adolescents with human immunodeficiency virus-1: application of focus group methodology to inform design, feasibility, and acceptability. *J Adolesc Health*. Feb 2009;44(2):124-132. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19167660](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19167660).
33. Gaur AH, Belzer M, Britto P, et al. Directly observed therapy (DOT) for nonadherent HIV-infected youth: lessons learned, challenges ahead. *AIDS Res Hum Retroviruses*. Sep 2010;26(9):947-953. Available at <http://www.ncbi.nlm.nih.gov/pubmed/20707731>.
34. Vermund SH, Wilson CM, Rogers AS, Partlow C, Moscicki AB. Sexually transmitted infections among HIV infected and HIV uninfected high-risk youth in the REACH study. Reaching for Excellence in Adolescent Care and Health. *J Adolesc Health*. Sep 2001;29(3 Suppl):49-56. Available at <http://www.ncbi.nlm.nih.gov/pubmed/11530303>.
35. Workowski KA, Berman S. Sexually transmitted diseases treatment guidelines, 2010. *MMWR Recomm Rep*. Dec 17 2010;59(RR-12):1-110. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=21160459](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=21160459).
36. Panel on Opportunistic Infections in HIV-Infected Adults and Adolescents. Guidelines for the prevention and treatment of opportunistic infections in HIV-infected adults and adolescents: recommendations from the Centers for Disease

Control and Prevention, the National Institutes of Health, and the HIV Medicine Association of the Infectious Diseases Society of America. 2014. Available at [http://aidsinfo.nih.gov/contentfiles/lvguidelines/adult\\_oi.pdf](http://aidsinfo.nih.gov/contentfiles/lvguidelines/adult_oi.pdf). Accessed January 15, 2016.

37. Panel on Opportunistic Infections in HIV-Exposed and HIV-Infected Children. Guidelines for the prevention and treatment of opportunistic infections in HIV-exposed and HIV-infected children. 2014. Available at [http://aidsinfo.nih.gov/contentfiles/lvguidelines/oi\\_guidelines\\_pediatrics.pdf](http://aidsinfo.nih.gov/contentfiles/lvguidelines/oi_guidelines_pediatrics.pdf). Accessed January 15, 2016.
38. Panel on Treatment of HIV-Infected Pregnant Women and Prevention of Perinatal Transmission. Recommendations for use of antiretroviral drugs in pregnant HIV-1-infected women for maternal health and interventions to reduce perinatal HIV transmission in the United States. 2014. Available at <http://aidsinfo.nih.gov/contentfiles/lvguidelines/PerinatalGL.pdf>. Accessed January 15, 2016.
39. Valenzuela JM, Buchanan CL, Radcliffe J, et al. Transition to adult services among behaviorally infected adolescents with HIV--a qualitative study. *J Pediatr Psychol*. Mar 2011;36(2):134-140. Available at <http://www.ncbi.nlm.nih.gov/pubmed/19542198>.
40. Committee On Pediatric A. Transitioning HIV-infected youth into adult health care. *Pediatrics*. Jul 2013;132(1):192-197. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23796739>.

### ***Treatment Challenges of HIV-Infected Illicit Drug Users***

Injection drug use is the second most common mode of HIV transmission in the United States. In addition, noninjection illicit drug use may facilitate sexual transmission of HIV. Injection and noninjection illicit drugs include the following: heroin, cocaine, marijuana, and club drugs (i.e., methamphetamine, ketamine, gamma-hydroxybutyrate [GHB], and amyl nitrate [i.e., poppers]). The most commonly used illicit drugs associated with HIV infection are heroin and stimulants (e.g., cocaine and amphetamines); however, the use of club drugs has increased substantially in the past several years and is common among individuals who have HIV infection or who are at risk of HIV infection. The association between club drugs and high-risk sexual behavior in men who have sex with men (MSM) is strongest for methamphetamine and amyl nitrate; this association is less consistent with the other club drugs.<sup>1</sup>

Illicit drug use has been associated with depression and anxiety, either as part of the withdrawal process or as a consequence of repeated use. This is particularly relevant in the treatment of HIV infection because depression is one of the strongest predictors of poor adherence and poor treatment outcomes.<sup>2</sup> Treatment of HIV disease in illicit drug users can be successful but HIV-infected illicit drug users present special treatment challenges. These challenges may include the following: (1) an array of complicating comorbid medical and mental health conditions; (2) limited access to HIV care; (3) inadequate adherence to therapy; (4) medication side effects and toxicities; (5) the need for substance abuse treatment; and (6) drug interactions that can complicate HIV treatment.<sup>3</sup>

Underlying health problems in injection and noninjection drug users result in increased morbidity and mortality, either independent of or accentuated by HIV disease. Many of these problems are the consequence of prior exposures to infectious pathogens from nonsterile needle and syringe use. Such problems can include hepatitis B or C virus infection, tuberculosis (TB), skin and soft tissue infections, recurrent bacterial pneumonia, and endocarditis. Other morbidities such as alteration in levels of consciousness and neurologic and renal disease are not uncommon. Furthermore, these comorbidities are associated with a higher risk of drug overdoses in illicit drug users with HIV disease than in HIV-uninfected illicit drug users, due in part to respiratory, hepatic, and neurological impairments associated with HIV infection.<sup>4</sup> Successful HIV therapy for illicit drug users often depends on clinicians becoming familiar with and managing these comorbid conditions and providing overdose prevention support.

Illicit drug users have less access to HIV care and are less likely to receive antiretroviral therapy (ART) than other populations.<sup>5-6</sup> Factors associated with low rates of ART use among illicit drug users include active drug use, younger age, female gender, suboptimal health care, recent incarceration, lack of access to rehabilitation programs, and health care providers' lack of expertise in HIV treatment.<sup>5-6</sup> The typically unstable, chaotic life patterns of many illicit drug users; the powerful pull of addictive substances; and common misperceptions about the dangers, impact, and benefits of ART all contribute to decreased adherence.<sup>7</sup> The chronic and relapsing nature of substance abuse as a biologic and medical disease, compounded by the high rate of mental illness that antedates and/or is exacerbated by illicit substance use, additionally complicate the relationship between health care workers and illicit drug users.<sup>8-9</sup> The first step in provision of care and treatment for these individuals is to recognize the existence of a substance abuse problem. It is often obvious that the problem exists, but some patients may hide these problem behaviors from clinicians. Assessment of a patient for substance abuse should be part of routine medical history taking and should be done in a professional, straightforward, and nonjudgmental manner.

### ***Treatment Efficacy in HIV-Infected Illicit Drug Use Populations***

Although illicit drug users are underrepresented in HIV therapy clinical trials, available data indicate that efficacy of ART in illicit drug users—when they are not actively using drugs—is similar to that seen in other



populations.<sup>10</sup> Furthermore, therapeutic failure in this population generally correlates with the degree that drug use disrupts daily activities rather than with drug use per se.<sup>11</sup> Providers need to remain attentive to the possible impact of disruptions caused by drug use on the patient both before and while receiving ART. Although many illicit drug users can sufficiently control their drug use for long enough time to benefit from care, substance abuse treatment is often necessary for successful HIV management.

Close collaboration with substance abuse treatment programs and proper support and attention to this population's special multidisciplinary needs are critical components of successful HIV treatment. Essential to this end are accommodating, flexible, community-based HIV care sites that are characterized by familiarity with and nonjudgmental expertise in management of drug users' wide array of needs and in development of effective strategies to promote medication adherence.<sup>9</sup> These strategies should include, if available, the use of adherence support mechanisms such as modified directly observed therapy (mDOT), which has shown promise in this population.<sup>12</sup>

### ***Antiretroviral Agents and Opioid Substitution Therapy***

Compared with noninjection drug users receiving ART, injection drug users (IDUs) receiving ART are more likely to experience an increased frequency of side effects and toxicities of ART. Although not systematically studied, this is likely because underlying hepatic, renal, neurologic, psychiatric, gastrointestinal (GI), and hematologic disorders are highly prevalent among IDUs. These comorbid conditions should be considered when selecting antiretroviral (ARV) agents in this population. Opioid substitution therapies such as methadone and buprenorphine/naloxone and extended-release naltrexone are commonly used for management of opioid dependence in HIV-infected patients.

**Methadone and Antiretroviral Therapy.** Methadone, an orally administered, long-acting opioid agonist, is the most common pharmacologic treatment for opioid addiction. Its use is associated with decreased heroin use, decreased needle sharing, and improved quality of life. Because of its opioid-induced effects on gastric emptying and the metabolism of cytochrome P (CYP) 450 isoenzymes 2B6, 3A4, and 2D6, pharmacologic effects and interactions with ARV agents may commonly occur.<sup>13</sup> These may diminish the effectiveness of either or both therapies by causing opioid withdrawal or overdose, increased methadone toxicity, and/or decreased ARV efficacy. Efavirenz (EFV), nevirapine (NVP), and lopinavir/ritonavir (LPV/r) have been associated with significant decreases in methadone levels. Patients and substance abuse treatment facilities should be informed of the likelihood of this interaction. The clinical effect is usually seen after 7 days of coadministration and may be managed by increasing the methadone dosage, usually in 5-mg to 10-mg increments daily until the desired effect is achieved.

**Buprenorphine and Antiretroviral Therapy.** Buprenorphine, a partial  $\mu$ -opioid agonist, is administered sublingually and is often coformulated with naloxone. It is increasingly used for opioid dependence treatment. Compared with methadone, buprenorphine has a lower risk of respiratory depression and overdose. This allows physicians in primary care to prescribe buprenorphine for the treatment of opioid dependency. The flexibility of the primary care setting can be of significant value to opioid-addicted HIV-infected patients who require ART because it enables one physician or program to provide both medical and substance abuse services. Limited information is currently available about interactions between buprenorphine and ARV agents.<sup>13-14</sup> Findings from available studies show that the drug interaction profile of buprenorphine is more favorable than that of methadone.

**Naltrexone and Antiretroviral Therapy.** A once-monthly extended-release intramuscular formulation of naltrexone was recently approved for prevention of relapse in patients who have undergone an opioid detoxification program. Naltrexone is also indicated for treatment of alcohol dependency. Naltrexone is not metabolized via the CYP450 enzyme system and is not expected to interact with protease inhibitors (PIs) or non-nucleoside reverse transcriptase inhibitors (NNRTIs).<sup>15</sup>

Currently available pharmacokinetic (PK) interaction data that clinicians can use as a guide for managing patients receiving ART and methadone or buprenorphine can be found in [Tables 19a-d](#). Particular attention is needed concerning communication between HIV care providers and drug treatment programs regarding additive drug toxicities and drug interactions resulting in opiate withdrawal or excess.

Methylenedioxymethamphetamine (MDMA), GHB, ketamine, and methamphetamine all have the potential to interact with ARV agents because all are metabolized, at least in part, by the CYP450 system. Overdoses secondary to interactions between the party drugs (i.e., MDMA or GHB) and PI-based ART have been reported.<sup>16</sup>

## Summary

It is usually possible over time to support most active drug users such that acceptable adherence levels with ARV agents can be achieved.<sup>17-18</sup> Providers must work to combine all available resources to stabilize an active drug user in preparation for ART. This should include identification of concurrent medical and psychiatric illnesses, drug treatment and needle and syringe exchange programs, strategies to reduce high-risk sexual behavior, and harm-reduction strategies. A history of drug use alone is insufficient reason to withhold ART because individuals with a history of prior drug use have adherence rates similar to those who do not abuse drugs.

Important considerations in the selection of successful regimens and the provision of appropriate patient monitoring in this population include need for supportive clinical sites; linkage to substance abuse treatment; and awareness of the interactions between illicit drugs and ARV agents, including the increased risk of side effects and toxicities. Simple regimens should be considered to enhance medication adherence. Preference should be given to ARV agents that have a lower risk of hepatic and neuropsychiatric side effects, simple dosing schedules, and minimal interaction with methadone.

## References

1. Colfax G, Guzman R. Club drugs and HIV infection: a review. *Clin Infect Dis*. May 15 2006;42(10):1463-1469.
2. Tucker JS, Burnam MA, Sherbourne CD, Kung FY, Gifford AL. Substance use and mental health correlates of nonadherence to antiretroviral medications in a sample of patients with human immunodeficiency virus infection. *Am J Med*. May 2003;114(7):573-580.
3. Bruce RD, Altice FL, Gourevitch MN, Friedland GH. Pharmacokinetic drug interactions between opioid agonist therapy and antiretroviral medications: implications and management for clinical practice. *J Acquir Immune Defic Syndr*. Apr 15 2006;41(5):563-572.
4. Wang C, Vlahov D, Galai N, et al. The effect of HIV infection on overdose mortality. *AIDS*. Jun 10 2005;19(9):935-942.
5. Strathdee SA, Palepu A, Cornelisse PG, et al. Barriers to use of free antiretroviral therapy in injection drug users. *JAMA*. Aug 12 1998;280(6):547-549.
6. Celentano DD, Vlahov D, Cohn S, Shadle VM, Obasanjo O, Moore RD. Self-reported antiretroviral therapy in injection drug users. *JAMA*. Aug 12 1998;280(6):544-546.
7. Altice FL, Mostashari F, Friedland GH. Trust and the acceptance of and adherence to antiretroviral therapy. *J Acquir Immune Defic Syndr*. Sep 1 2001;28(1):47-58.
8. Altice FL, Kamarulzaman A, Soriano VV, Schechter M, Friedland GH. Treatment of medical, psychiatric, and substance-use comorbidities in people infected with HIV who use drugs. *Lancet*. Jul 31 2010;376(9738):367-387.
9. Bruce RD, Altice FL, Friedland GH, Volberding P. HIV Disease Among Substance Misusers: Treatment Issues. *Global AIDS/HIV Medicine*. San Diego, CA: Elsevier Inc; 2007:513-526.
10. Morris JD, Golub ET, Mehta SH, Jacobson LP, Gange SJ. Injection drug use and patterns of highly active antiretroviral therapy use: an analysis of ALIVE, WIHS, and MACS cohorts. *AIDS Res Ther*. 2007;4:12.

11. Bouhnik AD, Chesney M, Carrieri P, et al. Nonadherence among HIV-infected injecting drug users: the impact of social instability. *J Acquir Immune Defic Syndr*. Dec 15 2002;31(Suppl 3):S149-153.
12. Altice FL, Maru DS, Bruce RD, Springer SA, Friedland GH. Superiority of directly administered antiretroviral therapy over self-administered therapy among HIV-infected drug users: a prospective, randomized, controlled trial. *Clin Infect Dis*. Sep 15 2007;45(6):770-778.
13. Gruber VA, McCance-Katz EF. Methadone, buprenorphine, and street drug interactions with antiretroviral medications. *Curr HIV/AIDS Rep*. Aug 2010;7(3):152-160.
14. Bruce RD, McCance-Katz E, Kharasch ED, Moody DE, Morse GD. Pharmacokinetic interactions between buprenorphine and antiretroviral medications. *Clin Infect Dis*. Dec 15 2006;43(Suppl 4):S216-223.
15. Food and Drug Administration (FDA). Vivitrol (package insert). October 2010.  
[http://www.accessdata.fda.gov/drugsatfda\\_docs/label/2010/021897s0151bl.pdf](http://www.accessdata.fda.gov/drugsatfda_docs/label/2010/021897s0151bl.pdf).
16. Bruce RD, Altice FL, Gourevitch MN, Friedland GH. A review of pharmacokinetic drug interactions between drugs of abuse and antiretroviral medications: Implications and management for clinical practice. *Exp Rev of Clin Pharmacol*. 2008;1(1):115-127.
17. Hicks PL, Mulvey KP, Chander G, et al. The impact of illicit drug use and substance abuse treatment on adherence to HAART. *AIDS Care*. Oct 2007;19(9):1134-1140.
18. Cofrancesco J, Jr., Scherzer R, Tien PC, et al. Illicit drug use and HIV treatment outcomes in a US cohort. *AIDS*. Jan 30 2008;22(3):357-365.

## HIV-Infected Women (Last updated February 12, 2013; last reviewed February 12, 2013)

### Panel's Recommendations

- The indications for initiation of antiretroviral therapy (ART) and the goals of treatment are the same for HIV-infected women as for other HIV-infected adults and adolescents (**AI**).
- Women taking antiretroviral (ARV) drugs that have significant pharmacokinetic interactions with oral contraceptives should use an additional or alternative contraceptive method to prevent unintended pregnancy (**AIII**).
- In pregnant women, an additional goal of therapy is prevention of perinatal transmission of HIV, with a goal of maximal viral suppression to reduce the risk of transmission of HIV to the fetus and newborn (**AI**).
- When selecting an ARV combination regimen for a pregnant woman, clinicians should consider the known safety, efficacy, and pharmacokinetic data on use during pregnancy for each agent (**AIII**).
- Women of childbearing potential should undergo pregnancy testing before initiation of efavirenz (EFV) and receive counseling about the potential risk to the fetus and desirability of avoiding pregnancy while on EFV-based regimens (**AIII**).
- Alternative regimens that do not include EFV should be strongly considered in women who are planning to become pregnant or sexually active and not using effective contraception, assuming these alternative regimens are acceptable to the provider and are not thought to compromise the woman's health (**BIII**).
- Because the risk of neural tube defects is restricted to the first 5 to 6 weeks of pregnancy and pregnancy is rarely recognized before 4 to 6 weeks of pregnancy, EFV can be continued in pregnant women receiving an EFV-based regimen who present for antenatal care in the first trimester, provided the regimen produces virologic suppression (**CIII**).
- When designing a regimen for a pregnant woman, clinicians should consult the most current Health and Human Services (HHS) Perinatal Guidelines (**AIII**).

**Rating of Recommendations:** A = Strong; B = Moderate; C = Optional

**Rating of Evidence:** I = Data from randomized controlled trials; II = Data from well-designed nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion

This section provides discussion of some basic principles and unique considerations to follow when caring for HIV-infected women, including during pregnancy. Clinicians who provide care for pregnant women should consult the current [Perinatal Guidelines](#)<sup>1</sup> for more in-depth discussion and management assistance. Additional guidance on the management of HIV-infected women can be found at <http://hab.hrsa.gov/deliverhivaidsare/clinicalguide11>.

### Gender Considerations in Antiretroviral Therapy

In general, studies to date have not shown gender differences in virologic responses to antiretroviral therapy (ART),<sup>2-4</sup> but a number of studies have suggested that gender may influence the frequency, presentation, and severity of selected antiretroviral (ARV)-related adverse events.<sup>5</sup> Although data are limited, evidence also exists that pharmacokinetics for some ARV drugs may differ between men and women, possibly because of variations between men and women in factors such as body weight, plasma volume, gastric emptying time, plasma protein levels, cytochrome P (CYP) 450 activity, drug transporter function, and excretion activity.<sup>6-8</sup>

### Adverse Effects:

- **Nevirapine (NVP)-associated hepatotoxicity:** NVP has been associated with an increased risk of symptomatic, potentially fatal, and often rash-associated liver toxicity in ARV-naïve individuals; women with higher CD4 counts ( $>250$  cells/mm<sup>3</sup>) or elevated baseline transaminase levels appear to be at greatest risk.<sup>9-12</sup> It is generally recommended that NVP not be prescribed to ARV-naïve women who have CD4 counts  $>250$  cells/mm<sup>3</sup> unless there is no other alternative and the benefit from NVP outweighs the risk of hepatotoxicity (**AI**).

- **Lactic acidosis:** There is a female predominance in the increased incidence of symptomatic and even fatal lactic acidosis associated with prolonged exposure to nucleoside reverse transcriptase inhibitors (NRTIs). Lactic acidosis is most common with stavudine (d4T), didanosine (ddI), and zidovudine (ZDV) but it can occur with other NRTIs.<sup>13</sup>
- **Metabolic complications:** A few studies have compared women and men in terms of metabolic complications associated with ARV use. Compared with HIV-infected men, HIV-infected women are more likely to experience increases in central fat with ART and are less likely to have triglyceride elevations on treatment.<sup>14, 15</sup> Women have an increased risk of osteopenia/osteoporosis, particularly after menopause, and this risk is exacerbated by HIV and ART.<sup>16, 17</sup> At the present time, none of these differences requires women-specific recommendations regarding treatment or monitoring.

## ***Women of Childbearing Potential***

All women of childbearing potential should be offered pre-conception counseling and care as a component of routine primary medical care. Counseling should include discussion of special considerations pertaining to ARV use when trying to conceive and during pregnancy (see [Perinatal Guidelines](#)<sup>1</sup>). Safe sexual practices, reproductive desires and options for conception, HIV status of sexual partner(s), and use of effective contraception to prevent unintended pregnancy should be discussed. An HIV-infected woman who wishes to conceive with an HIV-uninfected male partner should be informed of options to prevent sexual transmission of HIV while attempting conception. Interventions include initiation of maximally suppressive ART, which significantly decreases the risk of sexual transmission (see [Preventing Secondary Transmission of HIV](#)), and artificial insemination, including the option to self-inseminate with the partner's sperm during the periovulatory period<sup>18</sup> (for more extensive discussion on this topic, see the Reproductive Options for HIV-Concordant and Serodiscordant Couples section of the [Perinatal Guidelines](#).<sup>1</sup>

Efavirenz (EFV) is teratogenic in non-human primates. Women of childbearing potential should undergo pregnancy testing before initiation of EFV and receive counseling about the potential risk to the fetus and desirability of avoiding pregnancy while on EFV-based regimens (**AIII**). Alternative regimens that do not include EFV should be strongly considered in women who are planning to become pregnant or who are sexually active and not using effective contraception, assuming these alternative regimens are acceptable to the provider and are not thought to compromise the woman's health (**BIII**). The most vulnerable period in fetal organogenesis is early in gestation, before pregnancy is recognized.

## ***Hormonal Contraception***

Safe and effective reproductive health and family planning services to reduce unintended pregnancy and perinatal transmission of HIV are an essential component of care for HIV-infected women of childbearing age. Counseling about reproductive issues should be provided on an ongoing basis.

Providers should be aware of potential interactions between ARV drugs and hormonal contraceptives that could lower contraceptive efficacy. Several protease inhibitors (PIs) and non-nucleoside reverse transcriptase inhibitors (NNRTIs) have drug interactions with combined oral contraceptives (COCs). Interactions include either a decrease or an increase in blood levels of ethinyl estradiol, norethindrone, or norgestimate (see [Tables 20a and 20b](#)), which potentially decreases contraceptive efficacy or increases estrogen- or progestin-related adverse effects (e.g., thromboembolism). Small studies of HIV-infected women receiving injectable depot-medroxyprogesterone acetate (DMPA) while on ART showed no significant interactions between DMPA and EFV, NVP, nelfinavir (NFV), or NRTI drugs.<sup>19-21</sup> Contraceptive failure of the etonogestrel implant in two patients on EFV-based therapy has been reported and a study has shown EFV may decrease plasma progestin concentrations of COCs containing ethinyl estradiol and norgestimate.<sup>22, 23</sup> Several RTV-boosted PIs decrease oral contraceptive estradiol levels.<sup>24, 25</sup> A small study from Malawi showed that NVP use did not significantly affect estradiol or progestin levels in HIV-infected women.<sup>26</sup> Overall, data are



relatively limited and the clinical implications of these findings are unclear. The magnitudes of change in drug levels that may reduce contraceptive efficacy or increase adverse effects are unknown. Concerns about pharmacokinetic interactions between oral and implant hormonal contraceptives and ARVs should not prevent clinicians from prescribing hormonal contraceptives for women on ART if that is their preferred contraceptive method. However, when women wish to use hormonal contraceptives and drug interactions with ARVs are known, additional or alternative contraceptive methods may be recommended (see drug interaction [Tables 19a, 19b, and 19d](#) and [Perinatal Guidelines](#)<sup>1</sup>). Consistent use of male or female condoms to prevent transmission of HIV and protect against other sexually transmitted diseases (STDs) is recommended for all HIV-infected women and their partners, regardless of contraceptive use.

The data on the association between hormonal contraception and the risk of acquisition of HIV are conflicting.<sup>27</sup> A retrospective secondary analysis of two studies of serodiscordant couples in Africa in which the HIV-infected partner was not receiving ART found that women using hormonal contraception (the vast majority using injectable DMPA) had a twofold increased risk of acquiring HIV (for HIV-infected male/HIV-uninfected female couples) or transmitting HIV (HIV-infected female/HIV-uninfected male couples). HIV-infected women using hormonal contraception had higher genital HIV RNA concentrations than did women not using hormonal contraceptives.<sup>28</sup> Oral contraceptive use was not significantly associated with transmission of HIV; however, the number of women using oral contraceptives in this study was insufficient to adequately assess risk. It is important to note that not all studies have supported a link between hormonal contraception and transmission or acquisition of HIV and that the individuals in this study were not receiving ART. Further research is needed to definitively determine if hormonal contraceptive use is an independent risk factor for acquisition and transmission of HIV, particularly in the setting of ART.<sup>27, 29</sup>

Intrauterine devices (IUDs) appear to be a safe and effective contraceptive option for HIV-infected women.<sup>30-33</sup> Although studies have focused primarily on non-hormone-containing IUDs (e.g., copper IUD), several small studies have also found levonorgestrel-releasing IUDs to be safe and not associated with increased genital tract shedding of HIV.<sup>31, 34, 35</sup>

## ***Pregnant Women***

Clinicians should review the [Perinatal Guidelines](#)<sup>1</sup> for a detailed discussion of the management of HIV-infected pregnant women. The use of combination ARV regimens is recommended for all HIV-infected pregnant women, regardless of virologic, immunologic, or clinical parameters (**AI**). Pregnant HIV-infected women should be counseled regarding the known benefits and risks of ARV use during pregnancy to the woman, fetus, and newborn. A woman's decision regarding ARV use should be respected. Coercive and punitive approaches undermine provider-patient trust and could discourage women from seeking prenatal care and adopting health care behaviors that optimize maternal, fetal, and neonatal well-being.

**Prevention of Perinatal Transmission of HIV.** The use of ARVs and the resultant reduction of HIV RNA levels decrease perinatal transmission of HIV.<sup>36-38</sup> The goal of ARV use is to achieve maximal and sustained suppression of HIV RNA levels during pregnancy.

As in non-pregnant individuals, genotypic resistance testing is recommended for all pregnant women before ARV initiation (**AIII**) and for pregnant women with detectable HIV RNA levels while on therapy (**AI**). Optimal prevention of perinatal transmission may require initiation of ARV drugs before results of resistance testing are available. If results demonstrate the presence of significant mutation(s) that may confer resistance to the prescribed ARV regimen, the regimen should be modified.

Long-term follow-up is recommended for all infants born to women who have received ARVs during pregnancy, regardless of the infant's HIV status (see the [Perinatal Guidelines](#)<sup>1</sup>).

**Regimen Considerations.** Pregnancy should not preclude the use of optimal drug regimens. Because recommendations on ARVs to use for treatment of HIV-infected pregnant women are subject to unique

considerations, recommendations specific to the timing of therapy initiation and the choice of ARVs for pregnant women may differ from those for non-pregnant individuals. These considerations include the following:

- Potential changes in pharmacokinetics and, thus, dosing requirements, which result from physiologic changes associated with pregnancy;
- potential ARV-associated adverse effects in pregnant women and the woman's ability to adhere to a particular regimen during pregnancy; and
- potential short- and long-term effects of the ARV on the fetus and newborn, which are unknown for many drugs.

Combination drug regimens are considered the standard of care in pregnancy, both for the treatment of HIV infection and for the prevention of perinatal transmission of HIV. Because the risk of neural tube defects is restricted to the first 5 to 6 weeks of pregnancy and pregnancy is rarely recognized before 4 to 6 weeks of pregnancy, and unnecessary changes in ARV drugs during pregnancy may be associated with loss of viral control and increased risk of perinatal transmission, EFV can be continued in pregnant women receiving an EFV-based regimen who present for antenatal care in the first trimester, provided the regimen produces virologic suppression (**CIII**). Detailed recommendations on ARV choice in pregnancy are discussed in detail in the Perinatal Guidelines (see [Perinatal Guidelines](#)<sup>1</sup>).

Intravenous (IV) zidovudine (ZDV) infusion to the mother during labor is recommended if maternal HIV RNA is  $\geq 400$  copies/mL (or with unknown HIV RNA levels) near delivery, regardless of antepartum regimen or mode of delivery (**AI**). Consideration can be given to omitting IV ZDV infusion during labor for HIV-infected women receiving combination ART regimens who have HIV RNA  $< 400$  copies/mL near delivery (**BII**); however, the combination ART should continue to be administered during labor.

Clinicians who are treating HIV-infected pregnant women are strongly encouraged to report cases of prenatal exposure to ARVs (either administered alone or in combinations) to the Antiretroviral Pregnancy Registry (<http://www.apregistry.com>). The registry collects observational data regarding exposure to Food and Drug Administration-approved ARV drugs during pregnancy for the purpose of assessing potential teratogenicity. For more information regarding selection and use of ART during pregnancy, refer to the [Perinatal Guidelines](#).<sup>1</sup>

## **Postpartum Management**

Following delivery, clinical, immunologic, and virologic follow-up should continue as recommended for non-pregnant adults and adolescents. Because maternal ART reduces but does not eliminate the risk of transmission of HIV in breast milk and postnatal transmission can occur despite maternal ART, women should also be counseled to avoid breastfeeding.<sup>1</sup> HIV-infected women should avoid pre-mastication of food fed to their infants because the practice has been associated with transmission of HIV from mother to child.<sup>39</sup> Considerations regarding continuation of ART for maternal therapeutic indications are the same as those for ART use in other non-pregnant individuals. For more information regarding postpartum discontinuation of ART, refer to the [Perinatal Guidelines](#).<sup>1</sup>

Several studies have demonstrated that adherence to ART may worsen in the postpartum period.<sup>40-44</sup> Clinicians caring for women postpartum who are receiving ART should specifically address adherence, including an evaluation of specific facilitators and barriers to adherence. Clinicians may consider an intervention to improve adherence (see [Adherence to Antiretroviral Therapy](#)).

## **References**

1. Panel on Treatment of HIV-Infected Pregnant Women and Prevention of Perinatal Transmission. Recommendations for Use of Antiretroviral Drugs in Pregnant HIV-1-Infected Women for Maternal Health and Interventions to Reduce Perinatal HIV

Transmission in the United States. Available at <http://aidsinfo.nih.gov/contentfiles/lvguidelines/PerinatalGL.pdf>.

2. Collazos J, Asensi V, Carton JA. Sex differences in the clinical, immunological and virological parameters of HIV-infected patients treated with HAART. *AIDS*. 2007;21(7):835-843. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17415038](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17415038).
3. Fardet L, Mary-Krause M, Heard I, Partisani M, Costagliola D. Influence of gender and HIV transmission group on initial highly active antiretroviral therapy prescription and treatment response. *HIV Med*. 2006;7(8):520-529. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17105511](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17105511).
4. Currier J, Averitt Bridge D, Hagins D, et al. Sex-based outcomes of darunavir-ritonavir therapy: a single-group trial. *Ann Intern Med*. 2010;153(6):349-357. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=20855799](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20855799).
5. Clark RA, Squires KE. Gender-specific considerations in the antiretroviral management of HIV-infected women. *Expert Rev Anti Infect Ther*. 2005;3(2):213-227. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=15918779](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15918779).
6. Gandhi M, Aweeka F, Greenblatt RM, Blaschke TF. Sex differences in pharmacokinetics and pharmacodynamics. *Annu Rev Pharmacol Toxicol*. 2004;44:499-523. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=14744256](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=14744256).
7. Floridia M, Giuliano M, Palmisano L, Vella S. Gender differences in the treatment of HIV infection. *Pharmacol Res*. 2008;58(3-4):173-182. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18708144](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18708144).
8. Ofotokun I, Chuck SK, Hitti JE. Antiretroviral pharmacokinetic profile: a review of sex differences. *Gend Med*. 2007;4(2):106-119. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17707845](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17707845).
9. Baylor MS, Johann-Liang R. Hepatotoxicity associated with nevirapine use. *J Acquir Immune Defic Syndr*. 2004;35(5):538-539. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=15021321](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15021321).
10. Wit FW, Kesselring AM, Gras L, et al; for the ATHENA cohort study. Discontinuation of nevirapine because of hypersensitivity reactions in patients with prior treatment experience, compared with treatment-naïve patients. *Clin Infect Dis*. 2008;46(6):933-940. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18271750](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18271750).
11. Dieterich DT, Robinson PA, Love J, Stern JO. Drug-induced liver injury associated with the use of nonnucleoside reverse-transcriptase inhibitors. *Clin Infect Dis*. 2004;38 Suppl 2:S80-89. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=14986279](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=14986279).
12. Leith J, Piliero P, Storfer S, Mayers D, Hinzmann R. Appropriate use of nevirapine for long-term therapy. *J Infect Dis*. 2005;192(3):545-546; author reply 546. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=15995971](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15995971).
13. Lactic Acidosis International Study Group (LAISG). Risk factors for lactic acidosis and severe hyperlactataemia in HIV-1-infected adults exposed to antiretroviral therapy. *AIDS*. 2007;21(18):2455-2464. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18025882](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18025882).
14. Thiebaut R, Dequae-Merchadou L, Ekouevi DK, et al. Incidence and risk factors of severe hypertriglyceridaemia in the era of highly active antiretroviral therapy: the Aquitaine Cohort, France, 1996-99. *HIV Med*. 2001;2(2):84-88. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=11737383](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11737383).
15. Galli M, Veglia F, Angarano G, et al. Gender differences in antiretroviral drug-related adipose tissue alterations. Women are at higher risk than men and develop particular lipodystrophy patterns. *J Acquir Immune Defic Syndr*. 2003;34(1):58-61. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=14501794](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=14501794).
16. Yin M, Dobkin J, Brudney K, et al. Bone mass and mineral metabolism in HIV+ postmenopausal women. *Osteoporos Int*. 2005;16(11):1345-1352. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=15754081](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15754081).
17. Brown TT, Qaqish RB. Response to Berg et al. "Antiretroviral therapy and the prevalence of osteopenia and osteoporosis: a meta-analytic review." *AIDS*. 2007;21(13):1830-1831. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17690589](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17690589).

18. Lampe MA, Smith DK, Anderson GJ, Edwards AE, Nesheim SR. Achieving safe conception in HIV-discordant couples: the potential role of oral preexposure prophylaxis (PrEP) in the United States. *Am J Obstet Gynecol.* 2011;204(6):488 e481-488. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21457911>.
19. Cohn SE, Park JG, Watts DH, et al. Depo-medroxyprogesterone in women on antiretroviral therapy: effective contraception and lack of clinically significant interactions. *Clin Pharmacol Ther.* 2007;81(2):222-227. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17192768](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17192768).
20. Nanda K, Amaral E, Hays M, Viscola MA, Mehta N, Bahamondes L. Pharmacokinetic interactions between depot medroxyprogesterone acetate and combination antiretroviral therapy. *Fertil Steril.* 2008;90(4):965-971. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17880953](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17880953).
21. Watts DH, Park JG, Cohn SE, et al. Safety and tolerability of depot medroxyprogesterone acetate among HIV-infected women on antiretroviral therapy: ACTG A5093. *Contraception.* 2008;77(2):84-90. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18226670](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18226670).
22. Leticee N, Viard JP, Yamgnane A, Karmochkine M, Benachi A. Contraceptive failure of etonogestrel implant in patients treated with antiretrovirals including efavirenz. *Contraception.* 2011. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22036046>.
23. Sevensky H, Eley T, Persson A, et al. The effect of efavirenz on the pharmacokinetics of an oral contraceptive containing ethinyl estradiol and norgestimate in healthy HIV-negative women. *Antivir Ther.* 2011;16(2):149-156. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21447863>.
24. Vogler MA, Patterson K, Kamemoto L, et al. Contraceptive efficacy of oral and transdermal hormones when coadministered with protease inhibitors in HIV-1-infected women: pharmacokinetic results of ACTG trial A5188. *J Acquir Immune Defic Syndr.* 2010;55(4):473-482. Available at <http://www.ncbi.nlm.nih.gov/pubmed/20842042>.
25. Zhang J, Chung E, Yones C, et al. The effect of atazanavir/ritonavir on the pharmacokinetics of an oral contraceptive containing ethinyl estradiol and norgestimate in healthy women. *Antivir Ther.* 2011;16(2):157-164. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21447864>.
26. Stuart GS, Moses A, Corbett A, et al. Combined oral contraceptives and antiretroviral PK/PD in Malawian women: pharmacokinetics and pharmacodynamics of a combined oral contraceptive and a generic combined formulation antiretroviral in Malawi. *J Acquir Immune Defic Syndr.* 2011;58(2):e40-43. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21921726>.
27. Morrison CS, Nanda K. Hormonal contraception and HIV: an unanswered question. *Lancet Infect Dis.* 2012;12(1):2-3. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21975268>.
28. Heffron R, Donnell D, Rees H, et al. Use of hormonal contraceptives and risk of HIV-1 transmission: a prospective cohort study. *Lancet Infect Dis.* 2012;12(1):19-26. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21975269>.
29. Blish CA, Baeten JM. Hormonal contraception and HIV-1 transmission. *Am J Reprod Immunol.* 2011;65(3):302-307. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21087338>.
30. Stringer EM, Kaseba C, Levy J, et al. A randomized trial of the intrauterine contraceptive device vs hormonal contraception in women who are infected with the human immunodeficiency virus. *Am J Obstet Gynecol.* 2007;197(2):144 e141-148. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17689627](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17689627).
31. Heikinheimo O, Lehtovirta P, Aho I, Ristola M, Paavonen J. The levonorgestrel-releasing intrauterine system in human immunodeficiency virus-infected women: a 5-year follow-up study. *Am J Obstet Gynecol.* 2011;204(2):126 e121-124. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21035781>.
32. Curtis KM, Nanda K, Kapp N. Safety of hormonal and intrauterine methods of contraception for women with HIV/AIDS: a systematic review. *AIDS.* 2009;(23)(1):S55-67. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=20081389](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20081389).
33. U.S. Medical Eligibility Criteria for Contraceptive Use. Recommendations and Reports June 18, 2010 / 59(RR04);1-6; Prepared by Division of Reproductive Health, National Center for Chronic Disease Prevention and Health Promotion. 2010. Available at [http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5904a1.htm?s\\_cid=rr5904a1\\_e](http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5904a1.htm?s_cid=rr5904a1_e).
34. Heikinheimo O, Lahteenmaki P. Contraception and HIV infection in women. *Hum Reprod Update.* 2009;15(2):165-176. Available at <http://www.ncbi.nlm.nih.gov/pubmed/18978360>.
35. Lehtovirta P, Paavonen J, Heikinheimo O. Experience with the levonorgestrel-releasing intrauterine system among HIV-infected women. *Contraception.* 2007;75(1):37-39. Available at <http://www.ncbi.nlm.nih.gov/pubmed/17161122>.

36. Ioannidis JP, Abrams EJ, Ammann A, et al. Perinatal transmission of human immunodeficiency virus type 1 by pregnant women with RNA virus loads <1000 copies/ml. *J Infect Dis*. 2001;183(4):539-545. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=11170978](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11170978).
37. Mofenson LM, Lambert JS, Stiehler ER, et al; for Pediatric AIDS Clinical Trials Group Study 185 Team. Risk factors for perinatal transmission of human immunodeficiency virus type 1 in women treated with zidovudine. *N Engl J Med*. 1999;341(6):385-393. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=10432323](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=10432323).
38. Garcia PM, Kalish LA, Pitt J, et al; for the Women and Infants Transmission Study Group. Maternal levels of plasma human immunodeficiency virus type 1 RNA and the risk of perinatal transmission. *N Engl J Med*. 1999;341(6):394-402. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=10432324](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=10432324).
39. Gaur AH, Freimanis-Hance L, Dominguez K, et al. Knowledge and practice of prechewing/prewarming food by HIV-infected women. *Pediatrics*. 2011;127(5):e1206-1211. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=21482608](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=21482608).
40. Ickovics JR, Wilson TE, Royce RA, et al. Prenatal and postpartum zidovudine adherence among pregnant women with HIV: results of a MEMS substudy from the Perinatal Guidelines Evaluation Project. *J Acquir Immune Defic Syndr*. 2002;30(3):311-315. Available at <http://www.ncbi.nlm.nih.gov/pubmed/12131568>.
41. Bardeguet AD, Lindsey JC, Shannon M, et al. Adherence to antiretrovirals among US women during and after pregnancy. *J Acquir Immune Defic Syndr*. 2008;48(4):408-417. Available at <http://www.ncbi.nlm.nih.gov/pubmed/18614923>.
42. Mellins CA, Chu C, Malee K, et al. Adherence to antiretroviral treatment among pregnant and postpartum HIV-infected women. *AIDS Care*. 2008;20(8):958-968. Available at <http://www.ncbi.nlm.nih.gov/pubmed/18608073>.
43. Turner BJ, Newschaffer CJ, Zhang D, Cosler L, Hauck WW. Antiretroviral use and pharmacy-based measurement of adherence in postpartum HIV-infected women. *Med Care*. 2000;38(9):911-925. Available at <http://www.ncbi.nlm.nih.gov/pubmed/10982113>.
44. Rana AI, Gillani FS, Flanigan TP, Nash BT, Beckwith CG. Follow-up care among HIV-infected pregnant women in Mississippi. *J Womens Health (Larchmt)*. 2010;19(10):1863-1867. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=20831428](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20831428).



### Summary of HIV-2 Infection

- Compared to HIV-1 infection, the clinical course of HIV-2 infection is generally characterized by a longer asymptomatic stage, lower plasma HIV-2 RNA levels, and lower mortality; however, progression to AIDS does occur.
- There have been no randomized trials addressing the question of when to start antiretroviral therapy or the choice of initial or second-line therapy for HIV-2 infection; thus, the optimal treatment strategy has not been defined.
- Although the optimal CD4 T lymphocyte (CD4) cell count threshold for initiating antiretroviral therapy in HIV-2 infection is unknown, therapy should be started before there is clinical progression.
- HIV-2 is intrinsically resistant to non-nucleoside reverse transcriptase inhibitors and to enfuvirtide; thus, these drugs should not be included in an antiretroviral regimen for an HIV-2 infected patient.
- Pending more definitive data on outcomes in an antiretroviral therapy-naïve patient who has HIV-2 mono-infection or HIV-1/HIV-2 dual infection and requires treatment, an initial antiretroviral therapy regimen for these patients should include two nucleoside reverse transcriptase inhibitors plus an HIV-2 active boosted protease inhibitor or integrase strand transfer inhibitors.
- A few laboratories now offer quantitative plasma HIV-2 RNA testing for clinical care (see section text).
- Monitoring of HIV-2 RNA levels, CD4 cell counts, and clinical improvements can be used to assess treatment response, as is recommended for HIV-1 infection.
- Resistance-associated viral mutations to nucleoside reverse transcriptase inhibitors, protease inhibitors, and/or integrase strand transfer inhibitors may develop in HIV-2 infected patients while on therapy. However, no validated HIV-2 genotypic or phenotypic antiretroviral resistance assays are available for clinical use.
- In the event of virologic, immunologic, or clinical failure, second-line treatment should be instituted in consultation with an expert in HIV-2 management.

HIV-2 infection is endemic in West Africa. Although HIV-2 has had only limited spread outside this area, it should be considered in persons of West African origin or in those who have had sexual contact or shared needles with persons of West African origin. The prevalence of HIV-2 infection is also disproportionately high in countries with strong socioeconomic ties to West Africa (e.g., France; Spain; Portugal; and former Portuguese colonies such as Brazil, Angola, Mozambique, and parts of India).

### *Clinical Course of HIV-2 Infection*

Compared to HIV-1 infection, the clinical course of HIV-2 infection is generally characterized by a longer asymptomatic stage, lower plasma HIV-2 viral loads, and lower mortality rate.<sup>1,2</sup> However, HIV-2 infection can also progress to AIDS over time. Concomitant HIV-1 and HIV-2 infection may occur and should be considered in patients from areas with a high prevalence of HIV-2.

### *Diagnosis of HIV-2 Infection*

In the appropriate epidemiologic setting, HIV-2 infection should be suspected in patients with clinical conditions suggestive of HIV infection but with atypical serologic results (e.g., a positive screening assay with an indeterminate HIV-1 Western blot<sup>3</sup>). The possibility of HIV-2 infection should also be considered in the appropriate epidemiologic setting in patients with serologically confirmed HIV infection but low or undetectable HIV-1 RNA levels or in those with declining CD4 T lymphocyte (CD4) cell counts despite apparent virologic suppression on antiretroviral therapy (ART).

The 2014 Centers for Disease Control and Prevention guidelines for HIV diagnostic testing<sup>4</sup> recommend initial HIV testing using an HIV-1/HIV-2 antigen/antibody combination immunoassay and subsequent testing using an HIV-1/HIV-2 antibody differentiation immunoassay. The Multispot HIV-1/HIV-2 Rapid Test (Bio-Rad Laboratories) is Food and Drug Administration approved for differentiating HIV-1 from HIV-2 infection. Commercially available HIV-1 viral load assays do not reliably detect or quantify HIV-2.<sup>5,6</sup> Quantitative HIV-2 plasma RNA viral load testing has recently become available for clinical care at the University of Washington

(<http://depts.washington.edu/labweb/AboutLM/Contact.htm>)<sup>7</sup> and the New York State Department of Health ([http://www.wadsworth.org/divisions/infdis/hiv/Diagnostic\\_HIV\\_Testing\\_Services.html](http://www.wadsworth.org/divisions/infdis/hiv/Diagnostic_HIV_Testing_Services.html)).<sup>8</sup> However, it is important to note that approximately one-quarter to one-third of HIV-2-infected patients without ART will have HIV-2 RNA levels below the limits of detection; some of these patients will have clinical progression and CD4 cell count decline. No validated HIV-2 genotypic or phenotypic antiretroviral (ARV) resistance assays are available for clinical use.

## ***Treatment of HIV-2 Infection***

To date, no randomized trials addressing the question of when to start ART or the choice of initial or second-line therapy for HIV-2 infection have been completed;<sup>9</sup> thus, the optimal treatment strategy has not been defined. Three clinical trials to assess first-line ART for HIV-2 infection are currently underway; 2 are enrolling patients with CD4 counts <500 cells/mm<sup>3</sup> (NCT016058090 and NCT02180438) and 1 is enrolling patients with CD4 count >200 and ≤600 cells/mm<sup>3</sup> (NCT02150993). Although the optimal CD4 cell count threshold for initiating ART in HIV-2 infection is unknown, therapy should be started before there is clinical progression.

HIV-2 is intrinsically resistant to non-nucleoside reverse transcriptase inhibitors (NNRTI)<sup>10</sup> and to enfuvirtide (T20).<sup>11</sup> Data from *in vitro* studies suggest that HIV-2 is sensitive to the currently available nucleoside reverse transcriptase inhibitors (NRTIs), although with a lower barrier to resistance than HIV-1.<sup>12,13</sup> Darunavir (DRV), lopinavir (LPV), and saquinavir (SQV) are more active against HIV-2 than other approved protease inhibitors (PIs);<sup>14-17</sup> one of these boosted PIs should be used if a PI-based regimen is used. Other PIs should be avoided because of their lack of ARV activity and high failure rates. The integrase strand transfer inhibitors (INSTIs) raltegravir (RAL), elvitegravir (EVG), and dolutegravir (DTG) have potent activity against HIV-2.<sup>18-21</sup> The CCR5 antagonist maraviroc (MVC) appears active against some HIV-2 isolates;<sup>22</sup> however, no approved assays to determine HIV-2 co-receptor tropism exist and HIV-2 is known to use many other minor co-receptors in addition to CCR5 and CXCR4.<sup>23</sup>

Several small studies suggest poor responses in HIV-2 infected individuals treated with some ARV regimens including dual-NRTI regimens; regimens containing NNRTI plus 2NRTIs; and some unboosted PI-based regimens including nelfinavir (NFV) or indinavir (IDV) plus zidovudine (ZDV) and lamivudine (3TC); and atazanavir (ATV)-based regimens.<sup>9,24-27</sup> Clinical data on the effectiveness of triple-NRTI regimens are conflicting.<sup>28,29</sup> In general, HIV-2 active, boosted PI-containing regimens have resulted in more favorable virologic and immunologic responses than 2 or 3-NRTI-based regimens.<sup>29-31</sup> However, CD4 cell recovery on therapy are generally poorer than that observed for HIV-1.<sup>31-33</sup> INSTI-based regimens may also have favorable treatment responses.<sup>34,35</sup> A recent large systematic review of ART for HIV-2-infected patients (n = 17 studies, 976 HIV-2 infected patients) was unable to conclude which specific regimens are preferred.<sup>36</sup>

Resistance-associated viral mutations to NRTIs, PIs and/or INSTIs commonly develop in HIV-2 infected patients while on therapy.<sup>24,29,37-40,41</sup> Currently, HIV-2 transmitted drug resistance appears rare.<sup>42</sup> In one small study, DTG was found to have activity as a second-line INSTI in some HIV-2 patients with extensive ARV experience and RAL resistance.<sup>43</sup> Genotypic algorithms used to predict drug resistance in HIV-1 may not be applicable to HIV-2, because pathways and mutational patterns leading to resistance may differ between the HIV types.<sup>13,29,44</sup>

Some groups have recommended specific preferred and alternative regimens for initial therapy of HIV-2 infection;<sup>45-48</sup> however, currently, there are no controlled trial data to support the effectiveness of the recommended regimens. Pending more definitive data on outcomes in an ART-naïve patient who has HIV-2 mono-infection or HIV-1/HIV-2 dual infection and requires treatment, a regimen containing two NRTIs plus an HIV-2 active boosted PI or INSTI should be initiated in HIV-2 infected individuals.

HIV-2 plasma RNA levels, CD4 cell counts, and clinical improvements can be monitored to assess treatment response, as is recommended for HIV-1. Patients who have HIV-2 RNA levels below the limits of detection before therapy should still have HIV-2 plasma RNA monitoring, in addition to CD4 cell count and clinical

monitoring. In the event of virologic, immunologic, or clinical failure, second-line treatment should be instituted in consultation with an expert in HIV-2 management.

## References

1. Matheron S, Pueyo S, Damond F, et al. Factors associated with clinical progression in HIV-2 infected-patients: the French ANRS cohort. *AIDS*. 2003;17(18):2593-2601. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=14685053](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=14685053).
  2. Marlink R, Kanki P, Thior I, et al. Reduced rate of disease development after HIV-2 infection as compared to HIV-1. *Science*. 1994;265(5178):1587-1590. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=7915856](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=7915856).
  3. O'Brien TR, George JR, Epstein JS, Holmberg SD, Schochetman G. Testing for antibodies to human immunodeficiency virus type 2 in the United States. *MMWR Recomm Rep*. 1992;41(RR-12):1-9. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=1324395](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=1324395).
  4. Centers for Disease Control and Prevention, Association of Public Health Laboratories. Laboratory testing for the diagnosis of HIV infection: updated recommendations. 2014. Available at <http://stacks.cdc.gov/view/cdc/23447>.
  5. Chan PA, Wakeman SE, Flanigan T, Cu-Uvin S, Kojic E, Kantor R. HIV-2 diagnosis and quantification in high-risk patients. *AIDS Res Ther*. 2008;5:18. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18700986](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18700986).
  6. Damond F, Benard A, Balotta C, et al. An international collaboration to standardize HIV-2 viral load assays: results from the 2009 ACHI(E)V(2E) quality control study. *J Clin Microbiol*. 2011;49(10):3491-3497. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21813718>.
  7. Chang M, Gottlieb GS, Dragavon JA, et al. Validation for clinical use of a novel HIV-2 plasma RNA viral load assay using the Abbott m2000 platform. *J Clin Virol*. 2012;55(2):128-133. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22832059>.
  8. Styer LM, Miller TT, Parker MM. Validation and clinical use of a sensitive HIV-2 viral load assay that uses a whole virus internal control. *J Clin Virol*. 2013;58 Suppl 1:e127-133. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24342472>.
  9. Gottlieb GS, Eholie SP, Nkengasong JN, et al. A call for randomized controlled trials of antiretroviral therapy for HIV-2 infection in West Africa. *AIDS*. 2008;22(16):2069-2072; discussion 2073-2064. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18832869](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18832869).
  10. Tuaillon E, Gueudin M, Lemee V, et al. Phenotypic susceptibility to nonnucleoside inhibitors of virion-associated reverse transcriptase from different HIV types and groups. *J Acquir Immune Defic Syndr*. 2004;37(5):1543-1549. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=15577405](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15577405).
  11. Poveda E, Rodes B, Toro C, Soriano V. Are fusion inhibitors active against all HIV variants? *AIDS Res Hum Retroviruses*. 2004;20(3):347-348. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=15117459](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15117459).
  12. Boyer PL, Sarafianos SG, Clark PK, Arnold E, Hughes SH. Why do HIV-1 and HIV-2 use different pathways to develop AZT resistance? *PLoS Pathog*. 2006;2(2):e10. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=16485036](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16485036).
  13. Smith RA, Anderson DJ, Pyrak CL, Preston BD, Gottlieb GS. Antiretroviral drug resistance in HIV-2: three amino acid changes are sufficient for classwide nucleoside analogue resistance. *J Infect Dis*. 2009;199(9):1323-1326. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19358668](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19358668).
  14. Parkin NT, Schapiro JM. Antiretroviral drug resistance in non-subtype B HIV-1, HIV-2 and SIV. *Antivir Ther*. 2004;9(1):3-12. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=15040531](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15040531).
  15. Desbois D, Roquebert B, Peytavin G, et al. *In vitro* phenotypic susceptibility of human immunodeficiency virus type 2 clinical isolates to protease inhibitors. *Antimicrob Agents Chemother*. 2008;52(4):1545-1548. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18227188](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18227188).
  16. Brower ET, Bacha UM, Kawasaki Y, Freire E. Inhibition of HIV-2 protease by HIV-1 protease inhibitors in clinical use. *Chem Biol Drug Des*. 2008;71(4):298-305. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18312292](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18312292).
  17. Rodes B, Sheldon J, Toro C, Jimenez V, Alvarez MA, Soriano V. Susceptibility to protease inhibitors in HIV-2 primary
- Guidelines for the Use of Antiretroviral Agents in HIV-1-Infected Adults and Adolescents*

- isolates from patients failing antiretroviral therapy. *J Antimicrob Chemother.* 2006;57(4):709-713. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=16464891](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16464891).
18. Roquebert B, Damond F, Collin G, et al. HIV-2 integrase gene polymorphism and phenotypic susceptibility of HIV-2 clinical isolates to the integrase inhibitors raltegravir and elvitegravir *in vitro*. *J Antimicrob Chemother.* 2008;62(5):914-920. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18718922](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18718922).
  19. Charpentier C, Larrouy L, Collin G, et al. In-vitro phenotypic susceptibility of HIV-2 clinical isolates to the integrase inhibitor S/GSK1349572. *AIDS.* 2010;24(17):2753-2755. Available at <http://www.ncbi.nlm.nih.gov/pubmed/20827161>.
  20. Smith RA, Raugi DN, Pan C, et al. Three main mutational pathways in HIV-2 lead to high-level raltegravir and elvitegravir resistance: implications for emerging HIV-2 treatment regimens. *PLoS One.* 2012;7(9):e45372. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23028968>.
  21. Smith RA, Raugi DN, Pan C, et al. *In vitro* activity of dolutegravir against wild-type and integrase inhibitor-resistant HIV-2. *Retrovirology.* 2015;12(10). Available at <http://www.retrovirology.com/content/12/1/10>.
  22. Visseaux B, Charpentier C, Hurtado-Nedelec M, et al. *In vitro* phenotypic susceptibility of HIV-2 clinical isolates to CCR5 inhibitors. *Antimicrob Agents Chemother.* 2012;56(1):137-139. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22064539>.
  23. Owen SM, Ellenberger D, Rayfield M, et al. Genetically divergent strains of human immunodeficiency virus type 2 use multiple coreceptors for viral entry. *J Virol.* 1998;72(7):5425-5432. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=9620997](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=9620997).
  24. Gottlieb GS, Badiane NM, Hawes SE, et al. Emergence of multiclass drug-resistance in HIV-2 in antiretroviral-treated individuals in Senegal: implications for HIV-2 treatment in resource-limited West Africa. *Clin Infect Dis.* 2009;48(4):476-483. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19143530](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19143530).
  25. Jallow S, Kaye S, Alabi A, et al. Virological and immunological response to Combivir and emergence of drug resistance mutations in a cohort of HIV-2 patients in The Gambia. *AIDS.* 2006;20(10):1455-1458. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=16791023](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16791023).
  26. Adje-Toure CA, Cheingsong R, Garcia-Lerma JG, et al. Antiretroviral therapy in HIV-2-infected patients: changes in plasma viral load, CD4+ cell counts, and drug resistance profiles of patients treated in Abidjan, Cote d'Ivoire. *AIDS.* 2003;17 Suppl 3:S49-54. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=14565609](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=14565609).
  27. Cavaco-Silva J, Aleixo MJ, Van Laethem K, et al. Mutations selected in HIV-2-infected patients failing a regimen including atazanavir. *J Antimicrob Chemother.* 2013;68(1):190-192. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22977160>.
  28. Matheron S, Damond F, Benard A, et al. CD4 cell recovery in treated HIV-2-infected adults is lower than expected: results from the French ANRS CO5 HIV-2 cohort. *AIDS.* 2006;20(3):459-462. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=16439883](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16439883).
  29. Ruelle J, Roman F, Vandenbroucke AT, et al. Transmitted drug resistance, selection of resistance mutations and moderate antiretroviral efficacy in HIV-2: analysis of the HIV-2 Belgium and Luxembourg database. *BMC Infect Dis.* 2008;8:21. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18304321](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18304321).
  30. Benard A, Damond F, Campa P, et al. Good response to lopinavir/ritonavir-containing antiretroviral regimens in antiretroviral-naïve HIV-2-infected patients. *AIDS.* 2009;23(9):1171-1173. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19349850](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19349850).
  31. Ekouevi DK, Balestre E, Coffie PA, et al. Characteristics of HIV-2 and HIV-1/HIV-2 Dually Seropositive Adults in West Africa Presenting for Care and Antiretroviral Therapy: The IeDEA-West Africa HIV-2 Cohort Study. *PLoS One.* 2013;8(6):e66135. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23824279>.
  32. Drylewicz J, Matheron S, Lazaro E, et al. Comparison of viro-immunological marker changes between HIV-1 and HIV-2-infected patients in France. *AIDS.* 2008;22(4):457-468. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18301058](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18301058).
  33. Drylewicz J, Eholie S, Maiga M, et al. First-year lymphocyte T CD4+ response to antiretroviral therapy according to the HIV type in the IeDEA West Africa collaboration. *AIDS.* 2010;24(7):1043-1050. Available at <http://www.ncbi.nlm.nih.gov/pubmed/20397306>.
  34. Peterson K, Ruelle J, Vekemans M, Siegal FP, Deayton JR, Colebunders R. The role of raltegravir in the treatment of HIV-2 infections: evidence from a case series. *Antivir Ther.* 2012;17(6):1097-1100. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22892365>.



35. Zheng Y, Lambert C, Arendt V, Seguin-Devaux C. Virological and immunological outcomes of elvitegravir-based regimen in a treatment-naïve HIV-2-infected patient. *AIDS*. 2014;28(15):2329-2331. Available at <http://www.ncbi.nlm.nih.gov/pubmed/25313590>.
36. Ekouevi DK, Tchounga BK, Coffie PA, et al. Antiretroviral therapy response among HIV-2 infected patients: a systematic review. *BMC Infect Dis*. 2014;14:461. Available at <http://www.ncbi.nlm.nih.gov/pubmed/25154616>.
37. Damond F, Matheron S, Peytavin G, et al. Selection of K65R mutation in HIV-2-infected patients receiving tenofovir-containing regimen. *Antivir Ther*. 2004;9(4):635-636. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=15456096](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15456096).
38. Raugi DN, Smith RA, Ba S, et al. Complex patterns of protease inhibitor resistance among antiretroviral treatment-experienced HIV-2 patients from Senegal: implications for second-line therapy. *Antimicrob Agents Chemother*. 2013;57(6):2751-2760. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23571535>.
39. Charpentier C, Eholie S, Anglaret X, et al. Genotypic resistance profiles of HIV-2-treated patients in West Africa. *AIDS*. 2014;28(8):1161-1169. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24583671>.
40. Charpentier C, Roquebert B, Delelis O, et al. Hot spots of integrase genotypic changes leading to HIV-2 resistance to raltegravir. *Antimicrob Agents Chemother*. 2011;55(3):1293-1295. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21189351>.
41. Charpentier C, Camacho R, Ruelle J, et al. HIV-2EU: supporting standardized HIV-2 drug resistance interpretation in Europe. *Clin Infect Dis*. 2013;56(11):1654-1658. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23429380>.
42. Charpentier C, Visseaux B, Benard A, et al. Transmitted drug resistance in French HIV-2-infected patients. *AIDS*. 2013;27(10):1671-1674. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23595155>.
43. Descamps D, Peytavin G, Visseaux B, et al. Dolutegravir in HIV-2 infected patients with resistant virus to first-line integrase inhibitors from the French Named Patient Program. *Clin Infect Dis*. 2015. Available at <http://www.ncbi.nlm.nih.gov/pubmed/25690598>.
44. Gilleece Y, Chadwick DR, Breuer J, et al. British HIV Association guidelines for antiretroviral treatment of HIV-2-positive individuals 2010. *HIV Med*. 2010;11(10):611-619. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=20961377](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20961377).
45. New York State Department of Health AIDS Institute. Human Immunodeficiency Virus Type 2 (HIV-2). 2012. Available at <http://www.hivguidelines.org/wp-content/uploads/2014/04/human-immunodeficiency-virus-type-2-hiv-2.pdf>. Accessed March 10, 2015.
46. World Health Organization. Consolidated guidelines on the use of antiretroviral drugs for treating and preventing HIV infection. 2013. Available at [http://apps.who.int/iris/bitstream/10665/85321/1/9789241505727\\_eng.pdf](http://apps.who.int/iris/bitstream/10665/85321/1/9789241505727_eng.pdf). Accessed March 10, 2015.
47. Expert Group on the Medical Management of HIV Infected Individuals with the Ministry of Health and Sports. French HIV-2 Guidelines. 2010. Available at [http://www.sante.gouv.fr/IMG/pdf/Rapport\\_2010\\_sur\\_la\\_prise\\_en\\_charge\\_medicale\\_des\\_personnes\\_infectees\\_par\\_le\\_VIH\\_sous\\_la\\_direction\\_du\\_Pr\\_Patrick\\_Yeni.pdf](http://www.sante.gouv.fr/IMG/pdf/Rapport_2010_sur_la_prise_en_charge_medicale_des_personnes_infectees_par_le_VIH_sous_la_direction_du_Pr_Patrick_Yeni.pdf). Accessed February 9, 2015.
48. World Health Organization. What ARV regimen to start with in adults adolescents and pregnant women living with HIV-2? 2013. Available at [http://apps.who.int/iris/bitstream/10665/90772/1/WHO\\_HIV\\_2013.36\\_eng.pdf?ua=1](http://apps.who.int/iris/bitstream/10665/90772/1/WHO_HIV_2013.36_eng.pdf?ua=1). Accessed February 9, 2015.



### Key Considerations When Caring for Older HIV-Infected Patients Receiving Antiretroviral Therapy (ART)

- Antiretroviral therapy (ART) is recommended for all patients regardless of CD4 T lymphocyte cell count (**AI**). ART is especially important for older patients because they have a greater risk of serious non-AIDS complications and potentially a blunted immunologic response to ART.
- Adverse drug events from ART and concomitant drugs may occur more frequently in older HIV-infected patients than in younger HIV-infected patients. Therefore, the bone, kidney, metabolic, cardiovascular, and liver health of older HIV-infected patients should be monitored closely.
- Polypharmacy is common in older HIV patients; therefore, there is a greater risk of drug-drug interactions between antiretroviral drugs and concomitant medications. Potential for drug-drug interactions should be assessed regularly, especially when starting or switching ART and concomitant medications.
- HIV experts, primary care providers, **and other specialists** should work together to optimize the medical care of older HIV-infected patients with complex comorbidities.
- Early diagnosis of HIV and counseling to prevent secondary transmission of HIV remains an important aspect of the care of the older HIV-infected patient.

**Rating of Recommendations:** A = Strong; B = Moderate; C = Optional

**Rating of Evidence:** I = Data from randomized controlled trials; II = Data from well-designed nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion

Effective antiretroviral therapy (ART) has increased survival in HIV-infected individuals, resulting in an increasing number of older individuals living with HIV infection. **In the United States, among persons living with HIV infection at year-end 2013, 42% were age 50 years or older, 6% were age 65 or older, and trends suggest that these proportions will increase steadily.**<sup>1</sup> Care of HIV-infected patients increasingly will involve adults 60 to 80 years of age, a population for which data from clinical trials or pharmacokinetic (PK) studies are very limited.

There are several distinct areas of concern regarding the association between age and HIV disease.<sup>2</sup> First, older HIV-infected patients may suffer from aging-related comorbid illnesses that can complicate the management of HIV infection. Second, HIV disease may affect the biology of aging, possibly resulting in early manifestations of clinical syndromes generally associated with advanced age. Third, reduced mucosal and immunologic defenses (such as post-menopausal atrophic vaginitis) and changes in risk related-behaviors (e.g., decrease in condom use because of less concern about pregnancy or more high-risk sexual activity with increased use of erectile dysfunction drugs) in older adults could lead to increased risk of acquisition and transmission of HIV.<sup>3,4</sup> Finally, because older adults are generally perceived to be at low risk of HIV infection, screening for this population remains low.

### **HIV Diagnosis and Prevention in the Older Adult**

In older adults, failure to consider a diagnosis of HIV likely contributes to later initiation of ART.<sup>5</sup> **The Centers for Disease Control and Prevention (CDC) estimates that in 2013, 37% of adults aged 55 years or older at the time of HIV diagnosis met the case definition for AIDS. The comparable CDC estimates are 18% for adults aged 25 to 34 years and 30% for adults aged 35 to 44 years.**<sup>6</sup> In one observational cohort, older patients (defined as those  $\geq 35$  years of age) appeared to have lower CD4 T lymphocyte (CD4) cell counts at seroconversion, steeper CD4 count decline over time,<sup>7</sup> and tended to present to care with significantly lower CD4 counts.<sup>8</sup> When individuals  $>50$  years of age present with severe illnesses, AIDS-related opportunistic infections (OIs) need to be considered in the differential diagnosis of the illness.

Although many older individuals engage in risk behaviors associated with acquisition of HIV, they may see

themselves or be perceived by providers as at low risk of infection and, as a result, they are less likely to be tested for HIV infection than younger persons.<sup>9,10</sup> Despite CDC guidelines recommending HIV testing at least once in individuals aged 13 to 64, and more frequently for those at risk,<sup>11</sup> HIV testing prevalence remains low (<5%) among adults aged 50 to 64, and decreases with increasing age.<sup>12</sup> Clinicians must be attuned to the possibility of HIV infection in older adults, including those older than 64 years of age and especially in those who may engage in high-risk behaviors. Sexual history taking is therefore an important component of general health care for HIV-uninfected older adults, together with risk-reduction counseling, and screening for HIV and sexually transmitted infections (STIs), if indicated.

### ***Impact of Age on HIV Disease Progression***

HIV infection presents unique challenges in aging adults and these challenges may be compounded by ART:

- HIV infection itself is thought to induce immune-phenotypic changes akin to accelerated aging,<sup>13</sup> but recent laboratory and clinical data provide a more nuanced view of these changes. Some studies have shown that HIV-infected patients may exhibit chromosomal and immunologic features similar to those induced by aging.<sup>14,15</sup> However, other studies show the immunologic changes to be distinct from age-related changes.<sup>16</sup> In addition, although data on the increased incidence and prevalence of age-associated comorbidities in HIV patients are accumulating,<sup>17,18</sup> the age of diagnosis for myocardial infection and non-AIDS cancers in HIV-infected and HIV-uninfected patients is the same.<sup>18,19</sup>
- Older HIV patients have a greater incidence of complications and co-morbidities than HIV-uninfected adults of similar age, and may exhibit a frailty phenotype—defined clinically as a decrease in muscle mass, weight, physical strength, energy, and physical activity,<sup>20</sup> although the phenotype is still incompletely characterized in the HIV population.

### ***Initiating Antiretroviral Therapy in the Older HIV Patient***

ART is recommended for all HIV-infected individuals (AI; see [Initiation of Antiretroviral Therapy](#) section). Early treatment may be particularly important in older adults in part because of decreased immune recovery and increased risk of serious non-AIDS events in this population. In a modeling study based on data from an observational cohort, the beneficial effects of early ART were projected to be greatest in the oldest age group (patients between ages 45 and 65 years).<sup>21</sup> No data support a preference for any one of the Panel's recommended initial ART regimens (see [What to Start](#)) on the basis of patient age. The choice of regimen should instead be informed by a comprehensive review of the patient's other medical conditions and medications. The [What to Start](#) section ([Table 7](#)) of these guidelines provides guidance on selecting an antiretroviral regimen based on an older patient's characteristics and specific clinical conditions (e.g., kidney disease, elevated risk for cardiovascular disease, osteoporosis). In older patients with reduced renal function, dosage adjustment of nucleoside reverse transcriptase inhibitors (NRTIs) may be necessary (see [Appendix Table 7](#)). In addition, ARV regimen selection may be influenced by potential interaction of antiretroviral medications with drugs used concomitantly to manage co-morbidities (see [Tables 18-20b](#)). Adults age >50 years should be monitored for ART effectiveness and safety similarly to other HIV-infected populations [see [Table 3](#)]; however, in older patients, special attention should be paid to the greater potential for adverse effects of ART on renal, liver, cardiovascular, metabolic, and bone health (see [Table 14](#)).

### ***HIV, Aging, and Antiretroviral Therapy***

The efficacy, PKs, adverse effects, and drug interaction potentials of ART in the older adult have not been studied systematically. There is no evidence that the virologic response to ART differs in older and younger patients. In a recent observational study, a higher rate of viral suppression was seen in patients >55 years old than in younger patients.<sup>22</sup> However, ART-associated CD4 cell recovery in older patients is generally slower and lower in magnitude than in younger patients.<sup>8,23-25</sup> This observation suggests that starting ART at a younger age may result in better immunologic response and possibly clinical outcomes.

Hepatic metabolism and renal elimination are the major routes of drug clearance, including the clearance of ARV drugs. Both liver and kidney functions decrease with age and may result in impaired drug elimination and increased drug exposure.<sup>26</sup> Most clinical trials have included only a small proportion of participants over 50 years of age, and current ARV dosing recommendations are based on PK and pharmacodynamic data derived from participants with normal organ function. Whether drug accumulation in the older patient may lead to greater incidence and severity of adverse effects than seen in younger patients is unknown.

HIV-infected patients with aging-associated comorbidities may require additional pharmacologic interventions that can complicate therapeutic management. In addition to taking medications to manage HIV infection and comorbid conditions, many older HIV-infected patients also are taking medications to relieve discomfort (e.g., pain medications, sedatives) or to manage adverse effects of medications (e.g., anti-emetics). They also may self-medicate with over-the-counter medicines or supplements. In HIV-negative older patients, polypharmacy is a major cause of iatrogenic complications.<sup>27</sup> Some of these complications may be caused by medication errors (by prescribers or patients), medication non-adherence, additive drug toxicities, and drug-drug interactions. Older HIV-infected patients are probably at an even greater risk of polypharmacy-related adverse consequences than younger HIV-infected or similarly aged HIV-uninfected patients. When evaluating any new clinical complaint or laboratory abnormality in HIV-infected patients, especially in older patients, clinicians should always consider the possible role of adverse drug reactions from both ARV drugs and other concomitantly administered medications.

Drug-drug interactions are common with ART and can be easily overlooked by prescribers.<sup>28</sup> The available drug interaction information on ARV agents is derived primarily from PK studies performed in small numbers of relatively young, HIV-uninfected participants with normal organ function (see [Tables 18-20b](#)). Data from these studies provide clinicians with a basis to assess whether a significant interaction may exist. However, the magnitude of the interaction may be greater in older HIV-infected patients than in younger HIV-infected patients.

Nonadherence is the most common cause of treatment failure. Complex dosing requirements, high pill burden, inability to access medications because of cost or availability, limited health literacy including misunderstanding of instructions, depression, and neurocognitive impairment are among the key reasons for nonadherence.<sup>32</sup> Although many of these factors associated with non-adherence may be more prevalent in older patients, some studies have shown that older HIV-infected patients may actually be more adherent to ART than younger patients.<sup>29-31</sup> Clinicians should regularly assess older patients to identify any factors, such as neurocognitive deficits, that may decrease adherence. To facilitate medication adherence, it may be useful to discontinue unnecessary medications, simplify regimens, and recommend evidence-based behavioral approaches including the use of adherence aids such as pillboxes or daily calendars, and support from family members (see [Adherence to Antiretroviral Therapy](#)).

### ***Non-AIDS HIV-Related Complications and Other Comorbidities***

Among persons treated effectively with ART, as AIDS-related morbidity and mortality have decreased, non-AIDS conditions constitute an increasing proportion of serious illnesses.<sup>33-35</sup> Neurocognitive impairment, already a major health problem in aging adults, may be exacerbated by the effect of HIV infection on the brain.<sup>36</sup> In a prospective observational study, neurocognitive impairment was predictive of lower retention in care among older persons.<sup>37</sup> Neurocognitive impairment probably also affects adherence to therapy. Social isolation and depression are also particularly common among older HIV-infected adults and, in addition to their direct effects on morbidity and mortality, may contribute to poor medication adherence and retention in care.<sup>38,39</sup> Heart disease and cancer are the leading causes of death in older Americans.<sup>40</sup> Similarly, non-AIDS events such as heart disease, liver disease, and cancer have emerged as major causes of morbidity and mortality in HIV-infected patients receiving effective ART. The presence of multiple non-AIDS comorbidities coupled with the immunologic effects of HIV infection may add to the disease burden of aging

HIV-infected adults.<sup>41-43</sup> HIV-specific primary care guidelines have been updated with recommendations for lipid and glucose monitoring, evaluation and management of bone health, and management of kidney disease, and are available for clinicians caring for HIV-infected older patients.<sup>44-48</sup>

### ***Switching, Interrupting, and Discontinuing Antiretroviral Therapy in Older Patients***

Given the greater incidence of co-morbidities, non-AIDS complications and frailty among older HIV-infected patients, switching one or more ARVs in an HIV regimen may be necessary to minimize toxicities and drug-drug interactions. For example, expert guidance now recommends bone density monitoring in men aged  $\geq 50$  years and postmenopausal women, and suggests switching from tenofovir disoproxil fumarate or boosted protease inhibitors to other ARVs in older patients at high risk for fragility fractures.<sup>45</sup>

Few data exist on the use of ART in severely debilitated patients with chronic, severe, or non-AIDS terminal conditions.<sup>49,50</sup> Withdrawal of ART usually results in rebound viremia and a decline in CD4 cell count. Acute retroviral syndrome after abrupt discontinuation of ART has been reported. In severely debilitated patients, if there are no significant adverse reactions to ART, most clinicians would continue therapy. In cases where ART negatively affects quality of life, the decision to continue therapy should be made together with the patient and/or family members after a discussion on the risks and benefits of continuing or withdrawing ART.

### ***Healthcare Utilization, Cost Sharing, and End-of-Life Issues***

Important issues to discuss with aging HIV-infected patients are living wills, advance directives, and long-term care planning, including related financial concerns. Out-of-pocket health care expenses (e.g., copayments, deductibles), loss of employment, and other financial-related factors can cause temporary interruptions in treatment, including ART, which should be avoided whenever possible. The increased life expectancy and the higher prevalence of chronic complications in aging HIV populations can place greater demands upon HIV services.<sup>51</sup> Facilitating a patient's continued access to insurance can minimize treatment interruptions and reduce the need for other services to manage concomitant chronic disorders.

### ***Conclusion***

HIV disease can be overlooked in aging adults who tend to present with more advanced disease and experience accelerated CD4 loss. HIV induces immune-phenotypic changes that have been compared to accelerated aging. Effective ART has prolonged the life expectancy of HIV infected patients, increasing the number of patients  $>50$  years of age living with HIV. However, unique challenges in this population include greater incidence of complications and co-morbidities, and some of these complications may be exacerbated or accelerated by long term use of some ARV drugs. Providing comprehensive multidisciplinary medical and psychosocial support to patients and their families (the "Medical Home" concept) is of paramount importance in the aging population. Continued involvement of HIV experts, geriatricians, and other specialists in the care of older HIV-infected patients is warranted.

### **References**

1. Centers for Disease Control and Prevention. HIV Surveillance Report, 2014; vol. 26. 2015. Available at <http://www.cdc.gov/hiv/library/reports/surveillance/>. Accessed December 10, 2015.
2. Deeks SG, Phillips AN. HIV infection, antiretroviral treatment, ageing, and non-AIDS related morbidity. *BMJ*. 2009;338:a3172. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19171560](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19171560).
3. Levy JA, Ory MG, Crystal S. HIV/AIDS interventions for midlife and older adults: current status and challenges. *J Acquir Immune Defic Syndr*. Jun 1 2003;33 Suppl 2:S59-67. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=12853854](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=12853854).
4. Levy BR, Ding L, Lakra D, Kostes J, Niccolai L. Older persons' exclusion from sexually transmitted disease risk-reduction clinical trials. *Sex Transm Dis*. Aug 2007;34(8):541-544. Available at



[http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17297381](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17297381).

5. Althoff KN, Gebo KA, Gange SJ, et al. CD4 count at presentation for HIV care in the United States and Canada: are those over 50 years more likely to have a delayed presentation? *AIDS Res Ther*. 2010;7:45. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=21159161](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=21159161).
6. Centers for Disease Control and Prevention. Monitoring selected national HIV prevention and care objectives by using HIV surveillance data—United States and 6 U.S. dependent areas—2013. HIV Surveillance Supplemental Report 2015;20 (No. 2). 2015. Available at <http://www.cdc.gov/hiv/library/reports/surveillance/>. Accessed August 21, 2015.
7. Lodi S, Phillips A, Touloumi G, et al. Time from human immunodeficiency virus seroconversion to reaching CD4+ cell count thresholds <200, <350, and <500 Cells/mm(3): assessment of need following changes in treatment guidelines. *Clin Infect Dis*. Oct 2011;53(8):817-825. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21921225>.
8. Sabin CA, Smith CJ, d'Arminio Monforte A, et al. Response to combination antiretroviral therapy: variation by age. *AIDS*. Jul 31 2008;22(12):1463-1473. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18614870](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18614870).
9. Stone VE, Bounds BC, Muse VV, Ferry JA. Case records of the Massachusetts General Hospital. Case 29-2009. An 81-year-old man with weight loss, odynophagia, and failure to thrive. *N Engl J Med*. Sep 17 2009;361(12):1189-1198. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19759382](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19759382).
10. Ward EG, Disch WB, Schensul JJ, Levy JA. Understanding low-income, minority older adult self-perceptions of HIV risk. *J Assoc Nurses AIDS Care*. Jan-Feb 2011;22(1):26-37. Available at <http://www.ncbi.nlm.nih.gov/pubmed/20580270>.
11. Branson BM, Handsfield HH, Lampe MA, et al. Revised recommendations for HIV testing of adults, adolescents, and pregnant women in health-care settings. *MMWR Recomm Rep*. Sep 22 2006;55(RR-14):1-17. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=16988643](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16988643).
12. Ford CL, Godette DC, Mulatu MS, Gaines TL. Recent HIV testing prevalence, determinants, and disparities among U.S. older adult respondents to the behavioral risk factor surveillance system. *Sex Transm Dis*. Aug 2015;42(8):405-410. Available at <http://www.ncbi.nlm.nih.gov/pubmed/26165428>.
13. Martin J, Volberding P. HIV and premature aging: A field still in its infancy. *Ann Intern Med*. Oct 5 2010;153(7):477-479. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=20921548](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20921548).
14. Liu JC, Leung JM, Ngan DA, et al. Absolute leukocyte telomere length in HIV-infected and uninfected individuals: evidence of accelerated cell senescence in HIV-associated chronic obstructive pulmonary disease. *PLoS One*. 2015;10(4):e0124426. Available at <http://www.ncbi.nlm.nih.gov/pubmed/25885433>.
15. Zanet DL, Thorne A, Singer J, et al. Association between short leukocyte telomere length and HIV infection in a cohort study: No evidence of a relationship with antiretroviral therapy. *Clin Infect Dis*. May 2014;58(9):1322-1332. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24457340>.
16. Lee FJ, Amin J, Carr A. Efficacy of initial antiretroviral therapy for HIV-1 infection in adults: a systematic review and meta-analysis of 114 studies with up to 144 weeks' follow-up. *PLoS One*. 2014;9(5):e97482. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24830290>.
17. Schouten J, Wit FW, Stolte IG, et al. Cross-sectional comparison of the prevalence of age-associated comorbidities and their risk factors between HIV-infected and uninfected individuals: the AGEHIV cohort study. *Clin Infect Dis*. Dec 15 2014;59(12):1787-1797. Available at <http://www.ncbi.nlm.nih.gov/pubmed/25182245>.
18. Althoff KN, McGinnis KA, Wyatt CM, et al. Comparison of risk and age at diagnosis of myocardial infarction, end-stage renal disease, and non-AIDS-defining cancer in HIV-infected versus uninfected adults. *Clin Infect Dis*. Feb 15 2015;60(4):627-638. Available at <http://www.ncbi.nlm.nih.gov/pubmed/25362204>.
19. Rasmussen LD, May MT, Kronborg G, et al. Time trends for risk of severe age-related diseases in individuals with and without HIV infection in Denmark: a nationwide population-based cohort study. *Lancet HIV*. Jul 2015;2(7):e288-298. Available at <http://www.ncbi.nlm.nih.gov/pubmed/26423253>.
20. Althoff KN, Jacobson LP, Cranston RD, et al. Age, comorbidities, and AIDS predict a frailty phenotype in men who have sex with men. *J Gerontol A Biol Sci Med Sci*. Feb 2014;69(2):189-198. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24127428>.
21. Edwards JK, Cole SR, Westreich D, et al. Age at Entry Into Care, Timing of Antiretroviral Therapy Initiation, and 10-Year Mortality Among HIV-Seropositive Adults in the United States. *Clin Infect Dis*. Oct 1 2015;61(7):1189-1195. Available at <http://www.ncbi.nlm.nih.gov/pubmed/26082505>.
22. Horberg MA, Hurley LB, Klein DB, et al. The HIV Care Cascade Measured Over Time and by Age, Sex, and Race in a



- Large National Integrated Care System. *AIDS Patient Care STDS*. Nov 2015;29(11):582-590. Available at <http://www.ncbi.nlm.nih.gov/pubmed/26505968>.
23. Althoff KN, Justice AC, Gange SJ, et al. Virologic and immunologic response to HAART, by age and regimen class. *AIDS*. Oct 23 2010;24(16):2469-2479. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=20829678](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20829678).
  24. Bosch RJ, Bennett K, Collier AC, Zackin R, Benson CA. Pretreatment factors associated with 3-year (144-week) virologic and immunologic responses to potent antiretroviral therapy. *J Acquir Immune Defic Syndr*. Mar 1 2007;44(3):268-277. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17146370](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17146370).
  25. Nogueras M, Navarro G, Anton E, et al. Epidemiological and clinical features, response to HAART, and survival in HIV-infected patients diagnosed at the age of 50 or more. *BMC Infect Dis*. 2006;6:159. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17087819](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17087819).
  26. Sitar DS. Aging issues in drug disposition and efficacy. *Proc West Pharmacol Soc*. 2007;50:16-20. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18605223](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18605223).
  27. Steinman MA, Hanlon JT. Managing medications in clinically complex elders: "There's got to be a happy medium". *JAMA*. Oct 13 2010;304(14):1592-1601. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=20940385](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20940385).
  28. Marzolini C, Back D, Weber R, et al. Ageing with HIV: medication use and risk for potential drug-drug interactions. *J Antimicrob Chemother*. Sep 2011;66(9):2107-2111. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=21680580](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=21680580).
  29. Wellons MF, Sanders L, Edwards LJ, Bartlett JA, Heald AE, Schmadier KE. HIV infection: treatment outcomes in older and younger adults. *J Am Geriatr Soc*. Apr 2002;50(4):603-607. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=11982658](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11982658).
  30. Wutoh AK, Elekwachi O, Clarke-Tasker V, Daftary M, Powell NJ, Campusano G. Assessment and predictors of antiretroviral adherence in older HIV-infected patients. *J Acquir Immune Defic Syndr*. Jun 1 2003;33 Suppl 2:S106-114. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=12853859](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=12853859).
  31. Silverberg MJ, Leyden W, Horberg MA, DeLorenze GN, Klein D, Quesenberry CP, Jr. Older age and the response to and tolerability of antiretroviral therapy. *Arch Intern Med*. Apr 9 2007;167(7):684-691. [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17420427](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17420427).
  32. Gellad WF, Grenard JL, Marcum ZA. A systematic review of barriers to medication adherence in the elderly: looking beyond cost and regimen complexity. *Am J Geriatr Pharmacother*. Feb 2011;9(1):11-23. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=21459305](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=21459305).
  33. Justice AC. HIV and aging: time for a new paradigm. *Curr HIV/AIDS Rep*. May 2010;7(2):69-76. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=20425560](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20425560).
  34. Palella FJ, Jr., Baker RK, Moorman AC, et al. Mortality in the highly active antiretroviral therapy era: changing causes of death and disease in the HIV outpatient study. *J Acquir Immune Defic Syndr*. Sep 2006;43(1):27-34. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=16878047](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16878047).
  35. Smit C, Gekus R, Walker S, et al. Effective therapy has altered the spectrum of cause-specific mortality following HIV seroconversion. *AIDS*. Mar 21 2006;20(5):741-749. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=16514305](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16514305).
  36. Vance DE, Wadley VG, Crowe MG, Raper JL, Ball KK. Cognitive and everyday functioning in older and younger adults with and without HIV. *Clinical Gerontologists* 2011;34(5):413-426.
  37. Jacks A, Wainwright DA, Salazar L, et al. Neurocognitive deficits increase risk of poor retention in care among older adults with newly diagnosed HIV infection. *AIDS*. Aug 24 2015;29(13):1711-1714. Available at <http://www.ncbi.nlm.nih.gov/pubmed/26372282>.
  38. Grov C, Golub SA, Parsons JT, Brennan M, Karpiak SE. Loneliness and HIV-related stigma explain depression among older HIV-positive adults. *AIDS Care*. May 2010;22(5):630-639. Available at <http://www.ncbi.nlm.nih.gov/pubmed/20401765>.
  39. Kalichman SC, Heckman T, Kochman A, Sikkema K, Bergholte J. Depression and thoughts of suicide among middle-aged and older persons living with HIV-AIDS. *Psychiatr Serv*. Jul 2000;51(7):903-907. Available at <http://www.ncbi.nlm.nih.gov/pubmed/10875956>.

40. Kochanek KD, Xu J, Murphy SL, Minino AM, King HC. Deaths: Preliminary data for 2009. *National Vital Statistics Reports*. 2011;59(4):1-54. Available at
41. Guaraldi G, Orlando G, Zona S, et al. Premature age-related comorbidities among HIV-infected persons compared with the general population. *Clin Infect Dis*. Dec 2011;53(11):1120-1126. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=21998278](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=21998278).
42. Capeau J. Premature Aging and Premature Age-Related Comorbidities in HIV-Infected Patients: Facts and Hypotheses. *Clin Infect Dis*. Dec 2011;53(11):1127-1129. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=21998279](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=21998279).
43. Hasse B, Ledergerber B, Furrer H, et al. Morbidity and aging in HIV-infected persons: the Swiss HIV cohort study. *Clin Infect Dis*. Dec 2011;53(11):1130-1139. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=21998280](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=21998280).
44. Aberg JA, Gallant JE, Ghanem KG, Emmanuel P, Zingman BS, Horberg MA. Primary care guidelines for the management of persons infected with HIV: 2013 update by the HIV medicine association of the Infectious Diseases Society of America. *Clin Infect Dis*. Jan 2014;58(1):e1-34. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24235263>.
45. Brown TT, Hoy J, Borderi M, et al. Recommendations for evaluation and management of bone disease in HIV. *Clin Infect Dis*. Apr 15 2015;60(8):1242-1251. Available at <http://www.ncbi.nlm.nih.gov/pubmed/25609682>.
46. Lucas GM, Ross MJ, Stock PG, et al. Clinical practice guideline for the management of chronic kidney disease in patients infected with HIV: 2014 update by the HIV Medicine Association of the Infectious Diseases Society of America. *Clin Infect Dis*. Nov 1 2014;59(9):e96-138. Available at <http://www.ncbi.nlm.nih.gov/pubmed/25234519>.
47. American Academy of HIV Medicine. The HIV and Aging Consensus Project: Recommended treatment strategies for clinicians managing older patients with HIV. 2011. Available at [http://www.aahivm.org/Upload\\_Module/upload/HIV%20and%20Aging/Aging%20report%20working%20document%20FINAL.pdf](http://www.aahivm.org/Upload_Module/upload/HIV%20and%20Aging/Aging%20report%20working%20document%20FINAL.pdf). Accessed January 13, 2016.
48. Jacobson TA, Maki KC, Orringer CE, et al. National lipid association recommendations for patient-centered management of dyslipidemia: part 2. *J Clin Lipidol*. 2015.
49. Selwyn PA. Chapter 75. In: Berger AM S, JL, Von Roenn JH, ed. Palliative care in HIV/AIDS. In *Principles and Practice of Palliative Care and Supportive Oncology* 3rd Edition. Philadelphia, PA: Lippincott Williams and Wilkins; 2007:833-848.
50. Harding R, Simms V, Krakauer E, et al. Quality HIV Care to the End of life. *Clin Infect Dis*. Feb 15 2011;52(4):553-554; author reply 554. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=21258107](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=21258107).
51. Brennan A, Morley D, O'Leary AC, Bergin CJ, Horgan M. Determinants of HIV outpatient service utilization: a systematic review. *AIDS Behav*. Jan 2015;19(1):104-119. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24907780>.

# Considerations for Antiretroviral Use in Patients with Coinfections

## HIV/Hepatitis B Virus (HBV) Coinfection (Last updated January 10, 2011; last reviewed January 10, 2011)

### Panel's Recommendations

- Prior to initiation of antiretroviral therapy (ART), all patients who test positive for hepatitis B surface antigen (HBsAg) should be tested for hepatitis B virus (HBV) DNA using a quantitative assay to determine the level of HBV replication (**AIII**).
- Because emtricitabine (FTC), lamivudine (3TC), and tenofovir (TDF) have activity against both HIV and HBV, if HBV or HIV treatment is needed, ART should be initiated with the combination of TDF + FTC or TDF + 3TC as the nucleoside reverse transcriptase inhibitor (NRTI) backbone of a fully suppressive antiretroviral (ARV) regimen (**AI**).
- If HBV treatment is needed and TDF cannot safely be used, the alternative recommended HBV therapy is entecavir in addition to a fully suppressive ARV regimen (**BI**). Other HBV treatment regimens include peginterferon alfa monotherapy or adefovir in combination with 3TC or FTC or telbivudine in addition to a fully suppressive ARV regimen (**BII**).
- Entecavir has activity against HIV; its use for HBV treatment without ART in patients with dual infection may result in the selection of the M184V mutation that confers HIV resistance to 3TC and FTC. Therefore, entecavir must be used in addition to a fully suppressive ARV regimen when used in HIV/HBV-coinfected patients (**AII**).
- Discontinuation of agents with anti-HBV activity may cause serious hepatocellular damage resulting from reactivation of HBV; patients should be advised against self-discontinuation and carefully monitored during interruptions in HBV treatment (**AII**).
- If ART needs to be modified due to HIV virologic failure and the patient has adequate HBV suppression, the ARV drugs active against HBV should be continued for HBV treatment in combination with other suitable ARV agents to achieve HIV suppression (**AIII**).

**Rating of Recommendations:** A = Strong; B = Moderate; C = Optional

**Rating of Evidence:** I = Data from randomized controlled trials; II = Data from well-designed nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion

Approximately 5%–10% of HIV-infected persons also have chronic HBV infection, defined as testing positive for HBsAg for more than 6 months.<sup>1</sup> The progression of chronic HBV to cirrhosis, end-stage liver disease, and/or hepatocellular carcinoma is more rapid in HIV-infected persons than in persons with chronic HBV alone.<sup>2</sup> Conversely, chronic HBV does not substantially alter the progression of HIV infection and does not influence HIV suppression or CD4 cell responses following ART initiation.<sup>3–4</sup> However, several liver-associated complications that are ascribed to flares in HBV activity, discontinuation of dually active ARVs, or toxicity of ARVs can affect the treatment of HIV in patients with HBV coinfection.<sup>5–7</sup> These include the following:

- FTC, 3TC, and TDF are approved ARVs that also have antiviral activity against HBV. Discontinuation of these drugs may potentially cause serious hepatocellular damage resulting from reactivation of HBV.<sup>8</sup>
- Entecavir has activity against HIV; its use for HBV treatment without ART in patients with dual infection may result in the selection of the M184V mutation that confers HIV resistance to 3TC and FTC. Therefore, entecavir must be used in addition to a fully suppressive ARV regimen when used in HIV/HBV-coinfected patients (**AII**).<sup>9</sup>
- 3TC-resistant HBV is observed in approximately 40% of patients after 2 years on 3TC for chronic HBV and in approximately 90% of patients after 4 years when 3TC is used as the only active drug for HBV in coinfecting patients. Therefore, 3TC or FTC should be used in combination with other anti-HBV drugs (**AII**).<sup>10</sup>

- Immune reconstitution after initiation of treatment for HIV and/or HBV can be associated with elevation in transaminases, possibly because HBV is primarily an immune-mediated disease.<sup>11</sup>
- Some ARV agents can cause increases in transaminase levels. The rate and magnitude of these increases are higher with HBV coinfection.<sup>12-13</sup> The etiology and consequences of these changes in liver function tests are unclear because continuation of ART may be accompanied by resolution of the changes. Nevertheless, some experts suspend the implicated agent(s) when the serum alanine transferase (ALT) level is increased to 5–10 times the upper limit of normal. However, in HIV/HBV-coinfected persons, increases in transaminase levels can herald hepatitis B e antigen (HBeAg) seroconversion due to immune reconstitution, so the cause of the elevations should be investigated prior to the decision to discontinue medications. In persons with transaminase increases, HBeAg seroconversion should be evaluated by testing for HBeAg and anti-HBe as well as HBV DNA levels.

### ***Recommendations for HBV/HIV-Coinfected Patients***

- All patients with chronic HBV should be advised to abstain from alcohol, assessed for immunity to hepatitis A virus (HAV) infection (anti-HAV antibody total) and vaccinated if nonimmune, advised on methods to prevent HBV transmission (methods that do not differ from those to prevent HIV transmission), and evaluated for the severity of HBV infection as outlined in the [Guidelines for Prevention and Treatment of Opportunistic Infections in HIV-Infected Adults and Adolescents](#).<sup>14</sup>
- Prior to initiation of ART, all persons who test positive for HBsAg should be tested for HBV DNA using a quantitative assay to determine the level of HBV replication (**AIII**). Persons with chronic HBV infection already receiving ART active against HBV should undergo quantitative HBV DNA testing every 6–12 months to determine the effectiveness of therapy in suppressing HBV replication. The goal of HBV therapy with NRTIs is to prevent liver disease complications by sustained suppression of HBV replication to the lowest achievable level.
- **If not yet on therapy and HBV or HIV treatment is needed:** In persons without HIV infection, the recommended anti-HBV drugs for the treatment of persons naive to HBV therapy are TDF and entecavir.<sup>15-16</sup> In HIV-infected patients, however, only TDF can be considered part of the ARV regimen; entecavir has weak anti-HIV activity and must not be considered part of an ARV regimen. In addition, only TDF is fully active for the treatment of persons with known or suspected 3TC-resistant HBV infection. To avoid selection of HBV-resistant variants, when possible, these agents should not be used as the only agent with anti-HBV activity in an ARV regimen (**AIII**).

**Preferred regimen.** The combination of TDF + FTC or TDF + 3TC should be used as the NRTI backbone of a fully suppressive ARV regimen and for the treatment of HBV infection (**AII**).<sup>17-19</sup>

**Alternative regimens.** If TDF cannot safely be used, entecavir should be used in addition to a fully suppressive ARV regimen (**AII**); importantly, entecavir should not be considered to be a part of the ARV regimen<sup>20</sup> (**BII**). Due to a partially overlapping HBV-resistance pathway, it is not known if the combination of entecavir + 3TC or FTC will provide additional virologic or clinical benefit compared with entecavir alone. In persons with known or suspected 3TC-resistant HBV infection, the entecavir dose should be increased from 0.5 mg/day to 1 mg/day. However, entecavir resistance may emerge rapidly in patients with 3TC-resistant HBV infection. Therefore, entecavir should be used with caution in such patients with frequent monitoring (~ every 3 months) of the HBV DNA level to detect viral breakthrough. Other HBV treatment regimens include peginterferon alfa monotherapy or adefovir in combination with 3TC or FTC or telbivudine in addition to a fully suppressive ARV regimen,<sup>17, 21-22</sup> however, data on these regimens in persons with HIV/HBV coinfection are limited (**BII**). Due to safety concerns, peginterferon alfa should not be used in HIV/HBV-coinfected persons with cirrhosis.

- **Need to discontinue medications active against HBV:** The patient's clinical course should be monitored with frequent liver function tests. The use of adefovir dipivoxil, entecavir, or telbivudine to prevent flares, especially in patients with marginal hepatic reserve such as persons with compensated or decompensated cirrhosis, can be considered.<sup>8</sup> These alternative HBV regimens should only be used in addition to a fully suppressive ARV regimen.
- **Need to change ART because of HIV resistance:** If the patient has adequate HBV suppression, the ARV drugs active against HBV should be continued for HBV treatment in combination with other suitable ARV agents to achieve HIV suppression (**AIII**).

## References

1. Spradling PR, Richardson JT, Buchacz K, et al. Prevalence of chronic hepatitis B virus infection among patients in the HIV Outpatient Study, 1996-2007. *J Viral Hepat*. 2010.
2. Thio CL, Seaberg EC, Skolasky R, Jr., et al. HIV-1, hepatitis B virus, and risk of liver-related mortality in the Multicenter Cohort Study (MACS). *Lancet*. 2002;360(9349):1921-1926.
3. Konopnicki D, Mocroft A, de Wit S, et al. Hepatitis B and HIV: prevalence, AIDS progression, response to highly active antiretroviral therapy and increased mortality in the EuroSIDA cohort. *AIDS*. 2005;19(6):593-601.
4. Hoffmann CJ, Seaberg EC, Young S, et al. Hepatitis B and long-term HIV outcomes in coinfecting HAART recipients. *AIDS*. 2009;23(14):1881-1889.
5. Bellini C, Keiser O, Chave JP, et al. Liver enzyme elevation after lamivudine withdrawal in HIV-hepatitis B virus co-infected patients: the Swiss HIV Cohort Study. *HIV Med*. 2009;10(1):12-18.
6. Law WP, Dore GJ, Duncombe CJ, et al. Risk of severe hepatotoxicity associated with antiretroviral therapy in the HIV-NAT Cohort, Thailand, 1996-2001. *AIDS*. 2003;17(15):2191-2199.
7. Wit FW, Weverling GJ, Weel J, et al. Incidence of and risk factors for severe hepatotoxicity associated with antiretroviral combination therapy. *J Infect Dis*. 2002;186(1):23-31.
8. Dore GJ, Soriano V, Rockstroh J, et al. Frequent hepatitis B virus rebound among HIV-hepatitis B virus-coinfecting patients following antiretroviral therapy interruption. *AIDS*. 2010;24(6):857-865.
9. McMahon MA, Jilek BL, Brennan TP, et al. The HBV drug entecavir - effects on HIV-1 replication and resistance. *N Engl J Med*. 2007;356(25):2614-2621.
10. Benhamou Y, Bochet M, Thibault V, et al. Long-term incidence of hepatitis B virus resistance to lamivudine in human immunodeficiency virus-infected patients. *Hepatology*. 1999;30(5):1302-1306.
11. Manegold C, Hannoun C, Wywiol A, et al. Reactivation of hepatitis B virus replication accompanied by acute hepatitis in patients receiving highly active antiretroviral therapy. *Clin Infect Dis*. 2001;32(1):144-148.
12. Sulkowski MS, Thomas DL, Chaisson RE, et al. Hepatotoxicity associated with antiretroviral therapy in adults infected with human immunodeficiency virus and the role of hepatitis C or B virus infection. *JAMA*. 2000;283(1):74-80.
13. den Brinker M, Wit FW, Wertheim-van Dillen PM, et al. Hepatitis B and C virus co-infection and the risk for hepatotoxicity of highly active antiretroviral therapy in HIV-1 infection. *AIDS*. 2000;14(18):2895-2902.
14. Centers for Disease Control and Prevention (CDC). Guidelines for prevention and treatment of opportunistic infections in HIV-infected adults and adolescents: recommendations from CDC, the National Institutes of Health, and the HIV Medicine Association of the Infectious Diseases Society of America. *MMWR Recomm Rep*. 2009;58(RR-4):1-207.
15. Lok AS, McMahon BJ. Chronic hepatitis B: update 2009. *Hepatology*. 2009;50(3):661-662.
16. Woo G, Tomlinson G, Nishikawa Y, et al. Tenofovir and entecavir are the most effective antiviral agents for chronic hepatitis B: a systematic review and Bayesian meta-analyses. *Gastroenterology*. 2010;139(4):1218-1229.
17. Peters MG, Andersen J, Lynch P, et al. Randomized controlled study of tenofovir and adefovir in chronic hepatitis B virus and HIV infection: ACTG A5127. *Hepatology*. 2006;44(5):1110-1116.



18. Matthews GV, Seaberg E, Dore GJ, et al. Combination HBV therapy is linked to greater HBV DNA suppression in a cohort of lamivudine-experienced HIV/HBV coinfecting individuals. *AIDS*. 2009;23(13):1707-1715.
19. de Vries-Sluijs TE, Reijnders JG, Hansen BE, et al. Long-Term Therapy with Tenofovir is Effective for Patients Co-Infected with HIV and HBV. *Gastroenterology*. 2010.
20. Pessoa MG, Gazzard B, Huang AK, et al. Efficacy and safety of entecavir for chronic HBV in HIV/HBV coinfecting patients receiving lamivudine as part of antiretroviral therapy. *AIDS*. 2008;22(14):1779-1787.
21. Benhamou Y, Bochet M, Thibault V, et al. Safety and efficacy of adefovir dipivoxil in patients co-infected with HIV-1 and lamivudine-resistant hepatitis B virus: an open-label pilot study. *Lancet*. 2001;358(9283):718-723.
22. Ingiliz P, Valantin MA, Thibault V, et al. Efficacy and safety of adefovir dipivoxil plus pegylated interferon-alpha2a for the treatment of lamivudine-resistant hepatitis B virus infection in HIV-infected patients. *Antivir Ther*. 2008;13(7):895-900.

## Panel Recommendations

- All HIV-infected patients should be screened for hepatitis C virus infection (HCV). Patients at high risk of HCV infection should be screened annually and whenever HCV infection is suspected.
- Antiretroviral therapy may slow the progression of liver disease by preserving or restoring immune function and reducing HIV-related immune activation and inflammation. For most HIV/HCV-coinfected patients, including those with cirrhosis, the benefits of antiretroviral therapy outweigh concerns regarding drug-induced liver injury. Therefore, antiretroviral therapy should be initiated in most HIV/HCV-coinfected patients, regardless of CD4 T lymphocyte (CD4) cell count (**BII**).
- Initial antiretroviral therapy combination regimens recommended for most HIV/HCV-coinfected patients are the same as those recommended for individuals without HCV infection. However, when treatment for both HIV and HCV is indicated, the antiretroviral regimen should be selected with special considerations of potential drug-drug interactions and overlapping toxicities with the HCV treatment regimen (see discussion in the text below and in [Table 12](#)).
- Combined treatment of HIV and HCV can be complicated by drug-drug interactions, increased pill burden, and toxicities. Although antiretroviral therapy should be initiated for most HIV/HCV-coinfected patients regardless of CD4 cell count, in antiretroviral therapy-naïve patients with CD4 counts  $>500$  cells/mm<sup>3</sup> some clinicians may choose to defer antiretroviral therapy until HCV treatment is completed (**CIII**).
- In patients with lower CD4 counts (e.g.,  $<200$  cells/mm<sup>3</sup>), antiretroviral therapy should be initiated promptly (**AI**) and HCV therapy may be delayed until the patient is stable on HIV treatment (**CIII**).

**Rating of Recommendations:** A = Strong; B = Moderate; C = Optional

**Rating of Evidence:** I = Data from randomized controlled trials; II = Data from well-designed nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion

The management of hepatitis C virus (HCV)-infected patients is rapidly evolving. Data suggest that HIV/HCV-coinfected patients treated with all-oral HCV regimens have sustained virologic response rates comparable to those of HCV-monoinfected patients. The purpose of this section is to discuss hepatic safety and drug-drug interaction issues related to HIV/HCV coinfection and the concomitant use of antiretroviral (ARV) agents and HCV drugs. For specific guidance on HCV treatment, please refer to <http://www.hcvguidelines.org/>.

Among patients with chronic HCV infection, approximately one-third progress to cirrhosis, at a median time of less than 20 years.<sup>1,2</sup> The rate of progression increases with older age, alcoholism, male sex, and HIV infection.<sup>3-6</sup> A meta-analysis found that HIV/HCV-coinfected patients had a three fold greater risk of progression to cirrhosis or decompensated liver disease than HCV-monoinfected patients.<sup>5</sup> The risk of progression is even greater in HIV/HCV-coinfected patients with low CD4 T lymphocyte (CD4) cell counts. Although antiretroviral therapy (ART) appears to slow the rate of HCV disease progression in HIV/HCV-coinfected patients, several studies have demonstrated that the rate continues to exceed that observed in those without HIV infection.<sup>7,8</sup> Whether HCV infection accelerates HIV progression, as measured by AIDS-related opportunistic infections (OIs) or death,<sup>9</sup> is unclear. Although some older ARV drugs that are no longer commonly used have been associated with higher rates of hepatotoxicity in patients with chronic HCV infection,<sup>10,11</sup> newer ARV agents currently in use appear to be less hepatotoxic.

For more than a decade, the mainstay of treatment for HCV infection was a combination regimen of peginterferon and ribavirin (PegIFN/RBV), but this regimen was associated with a poor rate of sustained virologic response (SVR), especially in HIV/HCV-coinfected patients. Rapid advances in HCV drug development led to the discovery of new classes of direct acting antiviral (DAA) agents that target the HCV replication cycle. These new agents, when used with or without PegIFN and RBV, have been shown to achieve high SVR rates. The first DAA agents approved for the treatment of HCV infection in combination with PegIFN/RBV were the HCV protease inhibitors (PI), boceprevir and telaprevir. In HCV genotype 1

infected patients, the combined use of either boceprevir or telaprevir with PegIFN/RBV was associated with higher rates of SVR than use of PegIFN/RBV alone.<sup>12-15</sup> However, combined use of these drugs was associated with a large pill burden, increased dosing frequency, and adverse effects. Subsequently approved DAA agents in the same class and in newer classes that are used with or without RBV have higher SVR rates, reduced pill burden, less frequent dosing, fewer side effects, and shorter durations of therapy.<sup>14,16-19</sup> Therefore, the combination of boceprevir or telaprevir and PegIFN/RBV **is no longer recommended**, and has been replaced by newer combination regimens. Additional guidance on the treatment and management of HCV in HIV-infected and uninfected adults can be found at <http://www.hcvguidelines.org/>.<sup>20</sup>

### ***Assessment of HIV/Hepatitis C Virus Coinfection***

- All HIV-infected patients should be screened for HCV infection using sensitive immunoassays licensed for detection of antibody to HCV in blood.<sup>21</sup> At risk HCV-seronegative patients should undergo repeat testing annually. HCV-seropositive patients should be tested for HCV RNA using a sensitive quantitative assay to confirm the presence of active infection.<sup>22,23</sup> Patients who test HCV RNA-positive should undergo HCV genotyping and liver disease staging as recommended by the most updated HCV guidelines (see <http://www.hcvguidelines.org/>).
- Patients with HIV/HCV coinfection should be counseled to avoid consuming alcohol and to use appropriate precautions to prevent transmission of HIV and/or HCV to others. HIV/HCV-coinfected patients who are susceptible to hepatitis A virus (HAV) or hepatitis B virus (HBV) infection should be vaccinated against these viruses.
- All patients with HIV/HCV coinfection should be evaluated for HCV therapy.

### ***Antiretroviral Therapy in HIV/Hepatitis C Virus Coinfection***

#### **When to Start Antiretroviral Therapy**

The rate of liver disease (liver fibrosis) progression is accelerated in HIV/HCV-coinfected patients, particularly in individuals with low CD4 counts ( $\leq 350$  cells/mm<sup>3</sup>). Data largely from retrospective cohort studies are inconsistent regarding the effect of ART on the natural history of HCV disease;<sup>6,24,25</sup> however, some studies suggest that ART may slow the progression of liver disease by preserving or restoring immune function and by reducing HIV-related immune activation and inflammation.<sup>26-28</sup> Therefore, ART should be initiated in most HIV/HCV-coinfected patients, regardless of CD4 count (**BII**). However, in HIV treatment-naïve patients with CD4 counts  $>500$  cells/mm<sup>3</sup>, some clinicians may choose to defer ART until HCV treatment is completed to avoid drug-drug interactions (**CIII**). Compared to patients with CD4 counts  $>350$  cells/mm<sup>3</sup>, those with CD4 counts  $<200$  had lower HCV treatment response rates and higher rates of toxicity due to PegIFN/RBV.<sup>29</sup> Data regarding HCV treatment response to combination therapy with DAA agents in those with advanced immunosuppression is lacking. For patients with lower CD4 counts (e.g.,  $<200$  cells/mm<sup>3</sup>), ART should be initiated promptly (**AI**) and HCV therapy may be delayed until the patient is stable on HIV treatment (**CIII**).<sup>23,30-32</sup>

#### **Antiretroviral Drugs to Start and Avoid**

Initial ARV combination regimens recommended for most HIV treatment-naïve patients with HCV are the same as those recommended for patients without HCV infection. Special considerations for ARV selection in HIV/HCV-coinfected patients include the following:

- When both HIV and HCV treatments are indicated, the ARV regimen should be selected with special considerations of potential drug-drug interactions (see [Table 12](#)) and overlapping toxicities with the HCV treatment regimen.
- Cirrhotic patients should be carefully evaluated by an expert in advanced liver disease for signs of liver

decompensation according to the Child-Turcotte-Pugh classification system. This assessment is necessary because hepatically metabolized ARV and HCV DAA drugs may be contraindicated or require dose modification in patients with Child-Pugh class B and C disease (see [Appendix B, Table 7](#)).

## Hepatotoxicity

Drug-induced liver injury (DILI) following the initiation of ART is more common in HIV/HCV-coinfected patients than in those with HIV mono-infection. The greatest risk of DILI may be observed in coinfected individuals with advanced liver disease (e.g., cirrhosis, end-stage liver disease).<sup>33</sup> Eradication of HCV infection with treatment may decrease the likelihood of ARV-associated DILI.<sup>34</sup>

- Given the substantial heterogeneity in patient populations and drug regimens, comparison of DILI incidence rates for individual ARV agents across clinical trials is difficult. The incidence of significant elevations in liver enzyme levels (more than 5 times the upper limit of the normal laboratory reference range) is low with currently recommended ART regimens. Hypersensitivity (or allergic) reactions associated with rash and elevations in liver enzymes can occur with certain ARVs. Alanine aminotransferase (ALT) and aspartate aminotransferase (AST) levels should be monitored 2 to 8 weeks after initiation of ART and every 3 to 6 months thereafter. Mild to moderate fluctuations in ALT and/or AST are typical in individuals with chronic HCV infection. In the absence of signs and/or symptoms of liver disease or increases in bilirubin, these fluctuations do not warrant interruption of ART. Patients with significant ALT and/or AST elevation should be carefully evaluated for signs and symptoms of liver insufficiency and for alternative causes of liver injury (e.g., acute HAV or HBV infection, hepatobiliary disease, or alcoholic hepatitis). Short-term interruption of the ART regimen or of the specific drug suspected of causing the DILI may be required.<sup>35</sup>

## Concurrent Treatment of HIV and Hepatitis C Virus Infection

Concurrent treatment of HIV and HCV is feasible but may be complicated by pill burden, drug-drug interactions, and toxicities. In this context, the stage of HCV disease should be assessed to determine the medical need for HCV treatment and inform decision making on when to start HCV. Additional guidance on the treatment and management of HCV in HIV-infected and uninfected adults can be found at <http://www.hcvguidelines.org/>. If the decision is to treat HCV, the ART regimen may need to be modified before HCV treatment is initiated to reduce the potential for drug-drug interactions and/or toxicities that may develop during the period of concurrent HIV and HCV treatment. (See [Table 12](#) for recommendations on the concomitant use of selected drugs for treatment of HCV and HIV infection.) In patients with suppressed plasma HIV RNA and modified ART, HIV RNA should be measured within 4 to 8 weeks after changing HIV therapy to confirm the effectiveness of the new regimen. After completion of HCV treatment, the modified ART regimen should be continued for at least 2 weeks before reinitiating the original regimen. Continued use of the modified regimen is necessary because of the prolonged half-life of some HCV drugs and the potential risk of drug-drug interactions if a prior HIV regimen is resumed soon after HCV treatment is completed.

## Drug-Drug Interaction

Considerations for the concurrent use of ART and recommended HCV agents (per <http://hcvguidelines.org/>) are discussed below. [Table 12](#) provides recommendations on the concomitant use of selected drugs for treatment of HCV and HIV infection.

- Sofosbuvir is an HCV NS5B nucleotide polymerase inhibitors that is not metabolized by the cytochrome P450 enzyme system and, therefore, can be used in combination with most ARV drugs. Sofosbuvir is a substrate of p-glycoprotein (P-gp). P-gp inducers, such as tipranavir (TPV), may decrease sofosbuvir plasma concentrations and should not be co-administered with sofosbuvir. No other clinically significant pharmacokinetic interactions between sofosbuvir and ARVs have been identified. Drug-drug interaction studies in healthy volunteers did not find any significant interaction between sofosbuvir and

darunavir/ritonavir (DRV/r), efavirenz (EFV), rilpivirine (RPV), raltegravir (RAL), tenofovir disoproxil fumarate (TDF), or emtricitabine (FTC).<sup>36</sup> See [Table 12](#) for recommendations on the concomitant use of selected drugs for treatment of HCV and HIV infection.

- Ledipasvir is an HCV NS5A inhibitor and is part of a fixed-dose drug combination of sofosbuvir and ledipasvir.<sup>37</sup> Similar to sofosbuvir, ledipasvir is not metabolized by the cytochrome P450 system (CYP) of enzymes and is a substrate for P-gp. Ledipasvir is an inhibitor of the drug transporters P-gp and breast cancer resistance protein (BCRP) and may increase intestinal absorption of coadministered substrates for these transporters. The use of P-gp inducers is not recommended with ledipasvir/sofosbuvir. The coadministration of ledipasvir/sofosbuvir and ARV regimens containing TDF is associated with increased exposure to TDF, especially when TDF is taken with an HIV PI boosted with either RTV or cobicistat (COBI) (see [Table 12](#) for recommendations on the concomitant use of selected drugs for treatment of HCV and HIV infection). In some patients, alternative HCV or ARV drugs should be considered to avoid increases in TDF exposures. If the drugs are co-administered, the patient should be monitored for potential TDF-associated renal injury by assessing measurements of renal function (i.e., estimated creatinine clearance, serum phosphorus, urine glucose, and urine protein) before HCV treatment initiation and periodically during treatment.
- The fixed-dose drug combination of ombitasvir (a NS5A inhibitor), paritaprevir (an HCV PI), and RTV (a pharmacokinetic enhancer) is co-packaged and used in combination with dasabuvir, an NS5B inhibitor.<sup>38</sup> Paritaprevir is a substrate and inhibitor of the CYP3A4 enzymes and therefore may have significant interactions with certain ARVs that are metabolized by, or may induce or inhibit the same pathways. Dasabuvir is primarily metabolized by the CYP2C8 enzymes. Furthermore, ombitasvir, paritaprevir, and dasabuvir are inhibitors of UGT1A1 and also substrates of P-gp and BCRP. Paritaprevir is also a substrate and inhibitor of OATP1B1/3. Coadministration with drugs that are substrates or inhibitors of these enzymes and drug transporters may result in increased plasma concentrations of either the coadministered drug or the HCV drugs. Given that several CYP enzymes and drug transporters are involved in the metabolism of dasabuvir, ombitasvir, paritaprevir, and RTV, complex drug-drug interactions are likely. Therefore clinicians need to consider all coadministered drugs for potential drug-drug interactions. No significant drug-drug interactions have been found when dasabuvir, ombitasvir, paritaprevir, and RTV are used in conjunction with ATV or RAL. When either RTV or COBI is used in conjunction with ATV, the boosting agent should be discontinued during HCV therapy and ATV should be taken in the morning at the same time as ombitasvir, paritaprevir/r, and dasabuvir. RTV or COBI should be restarted after completion of HCV treatment. See [Table 12](#) for other recommendations for concomitant use of HCV drugs with ARVs. HIV-infected patients not on ART should be placed on an alternative HCV regimen because RTV has activity against HIV.
- Simeprevir is a HCV NS3/4A PI that has been studied in HIV/HCV-coinfected patients.<sup>39</sup> Simeprevir is a substrate and inhibitor of CYP3A4 and P gp enzymes, and therefore may have significant interactions with certain ARVs that are metabolized by the same pathways. Simeprevir is also an inhibitor of the drug transporter OATP1B1/3. On the basis of drug-drug interaction studies in healthy volunteers, simeprevir can be coadministered with RAL, DTG, RPV, and TDF.<sup>40</sup> However, coadministration of simeprevir with EFV, ETR, HIV PIs, COBI, or EVG/c/TDF/FTC **is not recommended**. (See [Table 12](#) for recommendations on the concomitant use of selected drugs for treatment of HCV and HIV infection.)

Given that the treatment of HCV is rapidly evolving, this section will be updated when new HCV drugs are approved that may have an impact on the treatment of HIV. For guidance on the treatment of HCV infection, refer to <http://www.hcvguidelines.org/>.



**Table 12. Concomitant Use of Selected HIV Drugs and FDA-Approved HCV Drugs for Treatment of HCV in HIV-Infected Adults** (page 1 of 3)

Recommendations in this table are based on available pharmacokinetics interaction data or predictions based on the known metabolic pathways of the HIV and HCV drugs. Whenever HIV and HCV drugs are used concomitantly, patients should be closely monitored for HIV and HCV virologic efficacy and potential toxicities. Given that the field of HCV therapy is rapidly evolving, clinicians should also refer to the latest drug product labels and HCV guidelines ([www.hcvguidelines.org/](http://www.hcvguidelines.org/)) for updated information.

Selected HIV Drugs	HCV DAA drugs				HCV Non-DAA Drugs	
	NS5B Inhibitor	Coformulated NS5A/NS5B Inhibitor	Coformulated NS5A/HCV PI Plus NS5B Inhibitor	HCV Protease Inhibitor <sup>a</sup>		
	Sofosbuvir	Ledipasvir/Sofosbuvir	Ombitasvir/Paritaprevir/Ritonavir Plus Dasabuvir <sup>b</sup>	Simeprevir	Ribavirin	Pegylated Interferon alpha
<b>NRTIs</b>						
3TC	✓	✓	✓	✓	✓	✓
ABC	✓	✓	✓	✓	✓	✓
FTC	✓	✓	✓	✓	✓	✓
TDF	✓	✓ Monitor for TDF toxicity	✓	✓	✓	✓
ZDV	✓	✓	✓	✓	✗ <sup>c</sup>	✗ <sup>d</sup>
<b>PIs</b>						
ATV (Unboosted)	✓	✓	✓ Reduce ATV dose to 300 mg and take in AM at same time as (ombitasvir/paritaprevir/r plus dasabuvir).  If RTV cannot be used, choose an alternative HCV regimen.	✗	✓	✓
ATV/r or ATV/c	✓	✓ If PI/r [or ATV/c, DRV/c] is used with TDF, ↑ TDF concentrations are expected. If coadministration necessary, monitor for TDF-associated toxicities (see footnote <sup>e</sup> )	✓ Take ATV 300 mg in AM at same time as (ombitasvir/paritaprevir/r plus dasabuvir); discontinue RTV or COBI in HIV regimen until HCV therapy completed.	✗	✓	✓
DRV/r or DRV/c	✓		✗	✗	✓	✓
FPV or FPV/r	✓		✗	✗	✓	✓
LPV/r	✓		✗	✗	✓	✓
SQV/r	✓		✗	✗	✓	✓

**Table 12. Concomitant Use of Selected HIV Drugs and FDA-Approved HCV Drugs for Treatment of HCV in HIV-Infected Adults** (page 2 of 3)

Selected HIV Drugs	HCV DAA drugs				HCV Non-DAA Drugs	
	NS5B Inhibitor	Coformulated NS5A/NS5B Inhibitor	Coformulated NS5A/HCV PI Plus NS5B Inhibitor	HCV Protease Inhibitor <sup>a</sup>		
	Sofosbuvir	Ledipasvir/Sofosbuvir	Ombitasvir/Paritaprevir/Ritonavir Plus Dasabuvir <sup>b</sup>	Simeprevir	Ribavirin	Pegylated Interferon alpha
PIs, continued						
TPV/r	✗	✗	✗	✗	✓	✓
NNRTIs						
EFV	✓	✓ If EFV used with TDF/FTC, monitor for TDF toxicity due to ↑ TDF concentrations	✗	✗	✓	✓
ETR	✓	✓	✗	✗	✓	✓
NVP	✓	✓	✗	✗	✓	✓
RPV	✓	✓	✗	✓	✓	✓
INSTIs						
DTG	✓	✓	?	✓	✓	✓
EVG/c/ TDF/FTC	✓	✗	✗	✗	✓	✓
EVG (plus PI/r Without COBI)	Refer to recommendations specific to each PI/r.					
RAL	✓	✓	✓	✓	✓	✓
CCR5 Antagonist						
MVC	✓	✓	✗	✓	✓	✓

✓ = ARV agents that can be used concomitantly

✗ = ARV agents not recommended

? = Data on PK interactions with the ARV drug are unavailable or insufficient to make a recommendation.

<sup>a</sup> Boceprevir is no longer recommended for HCV treatment and telaprevir is no longer available in the United States; therefore, these products have been removed from this table.

<sup>b</sup> Dasabuvir must be prescribed with ombitasvir/paritaprevir/ritonavir.

<sup>c</sup> Concomitant use of ZDV with ribavirin is not recommended given the potential for worsening anemia.

<sup>d</sup> Concomitant use of ZDV with pegylated interferon is not recommended given the potential for worsening neutropenia

<sup>e</sup> Consider alternative HCV or ARV therapy to avoid increases in TDF exposures. If coadministration is necessary, monitor for TDF-associated adverse reactions

**Table 12. Concomitant Use of Selected HIV Drugs and FDA-Approved HCV Drugs for Treatment of HCV in HIV-Infected Adults** (page 3 of 3)

**Key to Acronyms:** 3TC = lamivudine; ABC = abacavir; AM = morning; ART = antiretroviral therapy; ATV/r = atazanavir/ritonavir; ATV/c = atazanavir/cobicistat; COBI = cobicistat; DAA = direct-acting antiviral agents; DRV/r = darunavir/ritonavir; DRV/c = darunavir/cobicistat; DTG = dolutegravir; EFV = efavirenz; ETR = etravirine; EVG = elvitegravir; EVG/c = elvitegravir/cobicistat; FPV/r = fosamprenavir/ritonavir; FTC = emtricitabine; HCV = hepatitis C virus; INSTI = integrase strand transfer inhibitor; LPV/r = lopinavir/ritonavir; MVC = maraviroc; NVP = nevirapine; PI/r = ritonavir-boosted protease inhibitor; RAL = raltegravir; RPV = rilpivirine; RTV = ritonavir; SQV/r = saquinavir/ritonavir; TDF = tenofovir disoproxil fumarate; TPV/r = tipranavir/ritonavir; ZDV = zidovudine

## References

1. Alter MJ, Margolis HS, Krawczynski K, et al. The natural history of community-acquired hepatitis C in the United States. The Sentinel Counties Chronic non-A, non-B Hepatitis Study Team. *N Engl J Med*. 1992;327(27):1899-1905. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=1280771](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=1280771).
2. Thomas DL, Astemborski J, Rai RM, et al. The natural history of hepatitis C virus infection: host, viral, and environmental factors. *JAMA*. 2000;284(4):450-456. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=10904508](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=10904508).
3. Poynard T, Bedossa P, Opolon P. Natural history of liver fibrosis progression in patients with chronic hepatitis C. The OBSVIRC, METAVIR, CLINIVIR, and DOSVIRC groups. *Lancet*. 1997;349(9055):825-832. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=9121257](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=9121257).
4. Wiley TE, McCarthy M, Breidi L, Layden TJ. Impact of alcohol on the histological and clinical progression of hepatitis C infection. *Hepatology*. 1998;28(3):805-809. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=9731576](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=9731576).
5. Graham CS, Baden LR, Yu E, et al. Influence of human immunodeficiency virus infection on the course of hepatitis C virus infection: a meta-analysis. *Clin Infect Dis*. 2001;33(4):562-569. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=11462196](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11462196).
6. Thein HH, Yi Q, Dore GJ, Krahn MD. Natural history of hepatitis C virus infection in HIV-infected individuals and the impact of HIV in the era of highly active antiretroviral therapy: a meta-analysis. *AIDS*. 2008;22(15):1979-1991. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18784461](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18784461).
7. Weber R, Sabin CA, Friis-Moller N, et al. Liver-related deaths in persons infected with the human immunodeficiency virus: the D:A:D study. *Arch Intern Med*. 2006;166(15):1632-1641. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=16908797](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16908797).
8. Kitahata MM, Gange SJ, Abraham AG, et al. Effect of early versus deferred antiretroviral therapy for HIV on survival. *N Engl J Med*. 2009;360(18):1815-1826. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19339714](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19339714).
9. Greub G, Ledergerber B, Battegay M, et al. Clinical progression, survival, and immune recovery during antiretroviral therapy in patients with HIV-1 and hepatitis C virus coinfection: the Swiss HIV Cohort Study. *Lancet*. 2000;356(9244):1800-1805. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=11117912](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11117912).
10. Sulkowski MS, Thomas DL, Chaisson RE, Moore RD. Hepatotoxicity associated with antiretroviral therapy in adults infected with human immunodeficiency virus and the role of hepatitis C or B virus infection. *JAMA*. 2000;283(1):74-80. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=10632283](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=10632283).
11. Sulkowski MS, Thomas DL, Mehta SH, et al. Hepatotoxicity associated with nevirapine or efavirenz-containing antiretroviral therapy: role of hepatitis C and B infections. *Hepatology*. 2002;35(1):182-189. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list\\_uids=11786975&dopt=Abstract](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uids=11786975&dopt=Abstract).
12. Poordad F, McCone J, Jr., Bacon BR, et al. Boceprevir for untreated chronic HCV genotype 1 infection. *N Engl J Med*. 2011;364(13):1195-1206. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=21449783](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=21449783).
13. Jacobson IM, McHutchison JG, Dusheiko G, et al. Telaprevir for previously untreated chronic hepatitis C virus infection. *N Engl J Med*. 2011;364(25):2405-2416. Available at

[http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=21696307](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=21696307).

14. Zeuzem S, Andreone P, Pol S, et al. Telaprevir for retreatment of HCV infection. *N Engl J Med*. 2011;364(25):2417-2428. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21696308>.
15. Bacon BR, Gordon SC, Lawitz E, et al. Boceprevir for previously treated chronic HCV genotype 1 infection. *N Engl J Med*. 2011;364(13):1207-1217. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21449784>.
16. Afdhal N, Zeuzem S, Kwo P, et al. Ledipasvir and sofosbuvir for untreated HCV genotype 1 infection. *N Engl J Med*. 2014;370(20):1889-1898. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24725239>.
17. Kowdley KV, Gordon SC, Reddy KR, et al. Ledipasvir and sofosbuvir for 8 or 12 weeks for chronic HCV without cirrhosis. *N Engl J Med*. 2014;370(20):1879-1888. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24720702>.
18. Sulkowski MS, Gardiner DF, Rodriguez-Torres M, et al. Daclatasvir plus sofosbuvir for previously treated or untreated chronic HCV infection. *N Engl J Med*. 2014;370(3):211-221. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24428467>.
19. Feld JJ, Kowdley KV, Coakley E, et al. Treatment of HCV with ABT-450/r-ombitasvir and dasabuvir with ribavirin. *N Engl J Med*. 2014;370(17):1594-1603. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24720703>.
20. AASLD/IDSA/IAS-USA. Recommendations for testing, managing, and treating hepatitis C. Available at: <http://www.hcvguidelines.org>. Accessed November 5, 2014.
21. Panel on Antiretroviral Guidelines for Adults and Adolescents. Guidelines for the use of antiretroviral agents in HIV-1-infected adults and adolescents. 2014. Available at <http://aidsinfo.nih.gov/contentfiles/lvguidelines/AdultandAdolescentGL.pdf>. Accessed April 3, 2015.
22. Panel on Opportunistic Infections in HIV-Infected Adults and Adolescents. Guidelines for the prevention and treatment of opportunistic infections in HIV-infected adults and adolescents: recommendations from the Centers for Disease Control and Prevention, the National Institutes of Health, and the HIV Medicine Association of the Infectious Diseases Society of America. Available at [http://aidsinfo.nih.gov/contentfiles/lvguidelines/adult\\_oi.pdf](http://aidsinfo.nih.gov/contentfiles/lvguidelines/adult_oi.pdf). Accessed January 6, 2014.
23. Ghany MG, Strader DB, Thomas DL, Seeff LB. Diagnosis, management, and treatment of hepatitis C: an update. *Hepatology*. 2009;49(4):1335-1374. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19330875](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19330875).
24. Sulkowski MS, Mehta SH, Torbenson MS, et al. Rapid fibrosis progression among HIV/hepatitis C virus-co-infected adults. *AIDS*. 2007;21(16):2209-2216. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18090048](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18090048).
25. Brau N, Salvatore M, Rios-Bedoya CF, et al. Slower fibrosis progression in HIV/HCV-coinfected patients with successful HIV suppression using antiretroviral therapy. *J Hepatol*. 2006;44(1):47-55. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=16182404](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16182404).
26. Macias J, Berenguer J, Japon MA, et al. Fast fibrosis progression between repeated liver biopsies in patients coinfecting with human immunodeficiency virus/hepatitis C virus. *Hepatology*. 2009;50(4):1056-1063. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19670415](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19670415).
27. Verma S, Goldin RD, Main J. Hepatic steatosis in patients with HIV-Hepatitis C Virus coinfection: is it associated with antiretroviral therapy and more advanced hepatic fibrosis? *BMC Res Notes*. 2008;1:46. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18710499](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18710499).
28. Ragni MV, Nalesnik MA, Schillo R, Dang Q. Highly active antiretroviral therapy improves ESLD-free survival in HIV-HCV co-infection. *Haemophilia*. 2009;15(2):552-558. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19347994](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19347994).
29. Opravil M, Sasadeusz J, Cooper DA, et al. Effect of baseline CD4 cell count on the efficacy and safety of peginterferon Alfa-2a (40KD) plus ribavirin in patients with HIV/hepatitis C virus coinfection. *J Acquir Immune Defic Syndr*. 2008;47(1):36-49. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=18156990](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=18156990).
30. Soriano V, Puoti M, Sulkowski M, et al. Care of patients coinfecting with HIV and hepatitis C virus: 2007 updated recommendations from the HCV-HIV International Panel. *AIDS*. 2007;21(9):1073-1089. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17502718](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17502718).
31. Tien PC. Management and treatment of hepatitis C virus infection in HIV-infected adults: recommendations from the Veterans Affairs Hepatitis C Resource Center Program and National Hepatitis C Program Office. *Am J Gastroenterol*. 2005;100(10):2338-2354. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=16181388](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16181388).

32. Avidan NU, Goldstein D, Rozenberg L, et al. Hepatitis C viral kinetics during treatment with peg IFN-alpha-2b in HIV/HCV coinfecting patients as a function of baseline CD4+ T-cell counts. *J Acquir Immune Defic Syndr*. 2009;52(4):452-458. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=19797971](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19797971).
33. Aranzabal L, Casado JL, Moya J, et al. Influence of liver fibrosis on highly active antiretroviral therapy-associated hepatotoxicity in patients with HIV and hepatitis C virus coinfection. *Clin Infect Dis*. 2005;40(4):588-593. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=15712082](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15712082).
34. Labarga P, Soriano V, Vispo ME, et al. Hepatotoxicity of antiretroviral drugs is reduced after successful treatment of chronic hepatitis C in HIV-infected patients. *J Infect Dis*. 2007;196(5):670-676. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17674307](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17674307).
35. Sulkowski MS, Thomas DL. Hepatitis C in the HIV-infected patient. *Clin Liver Dis*. 2003;7(1):179-194. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=12691466](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=12691466).
36. Sovaldi [package insert]. Food and Drug Administration. 2013. Available at [http://www.accessdata.fda.gov/drugsatfda\\_docs/label/2013/204671s000lbl.pdf](http://www.accessdata.fda.gov/drugsatfda_docs/label/2013/204671s000lbl.pdf). Accessed November 5, 2014.
37. Harvoni [package insert]. Food and Drug Administration. 2014. Available at [http://www.gilead.com/~media/Files/pdfs/medicines/liver-disease/harvoni/harvoni\\_pi.pdf](http://www.gilead.com/~media/Files/pdfs/medicines/liver-disease/harvoni/harvoni_pi.pdf). Accessed November 5, 2014.
38. Viekira Pak [package insert]. Food and Drug Administration. 2014. Available at [http://www.accessdata.fda.gov/drugsatfda\\_docs/label/2014/206619lbl.pdf](http://www.accessdata.fda.gov/drugsatfda_docs/label/2014/206619lbl.pdf). Accessed February 10, 2015.
39. Dieterich D, Rockstroh JK, Orkin C, et al. Simeprevir (TMC435) With Pegylated Interferon/Ribavirin in Patients Coinfected With HCV Genotype 1 and HIV-1: A Phase 3 Study. *Clin Infect Dis*. 2014. Available at <http://www.ncbi.nlm.nih.gov/pubmed/25192745>.
40. OLYSIO [package insert]. Label Food and Drug Administration. 2013. Available at [http://www.accessdata.fda.gov/drugsatfda\\_docs/label/2013/205123s001lbl.pdf](http://www.accessdata.fda.gov/drugsatfda_docs/label/2013/205123s001lbl.pdf). Accessed November 5, 2014.



## Mycobacterium Tuberculosis Disease with HIV Coinfection (Last updated March 27, 2012; last reviewed March 27, 2012)

### Panel's Recommendations

- The principles for treatment of active tuberculosis (TB) disease in HIV-infected patients are the same as those for HIV-uninfected patients **(AI)**.
- All HIV-infected patients with diagnosed active TB should be started on TB treatment immediately **(AI)**.
- All HIV-infected patients with diagnosed active TB should be treated with antiretroviral therapy (ART) **(AI)**.
- In patients with CD4 counts  $<50$  cells/mm<sup>3</sup>, ART should be initiated within 2 weeks of starting TB treatment **(AI)**.
- In patients with CD4 counts  $\geq 50$  cells/mm<sup>3</sup> who present with clinical disease of major severity as indicated by clinical evaluation (including low Karnofsky score, low body mass index [BMI], low hemoglobin, low albumin, organ system dysfunction, or extent of disease), ART should be initiated within 2 to 4 weeks of starting TB treatment. The strength of this recommendation varies on the basis of CD4 cell count:
  - CD4 count 50 to 200 cells/mm<sup>3</sup> **(BI)**
  - CD4 count  $>200$  cells/mm<sup>3</sup> **(BIII)**
- In patients with CD4 counts  $\geq 50$  cells/mm<sup>3</sup> who do not have severe clinical disease, ART can be delayed beyond 2 to 4 weeks of starting TB therapy but should be started within 8 to 12 weeks of TB therapy initiation. The strength of this recommendation also varies on the basis of CD4 cell count:
  - CD4 count 50 to 500 cells/mm<sup>3</sup> **(AI)**
  - CD4 count  $>500$  cells/mm<sup>3</sup> **(BIII)**
- In all HIV-infected pregnant women with active TB, ART should be started as early as feasible, both for maternal health and for prevention of mother-to-child transmission (PMTCT) of HIV **(AIII)**.
- In HIV-infected patients with documented multidrug-resistant (MDR) and extensively drug-resistant (XDR) TB, ART should be initiated within 2 to 4 weeks of confirmation of TB drug resistance and initiation of second-line TB therapy **(BIII)**.
- Despite pharmacokinetic drug interactions, a rifamycin (rifampin or rifabutin) should be included in TB regimens for patients receiving ART, with dosage adjustment if necessary **(AII)**.
- Rifabutin is the preferred rifamycin to use in HIV-infected patients with active TB disease on a protease inhibitor (PI)-based regimen because the risk of substantial drug interactions with PIs is lower with rifabutin than with rifampin **(AII)**.
- Coadministration of rifampin and PIs (with or without ritonavir [RTV] boosting) is not recommended **(AII)**.
- Rifapentine (RPT) is NOT recommended in HIV-infected patients receiving ART for treatment of latent TB infection (LTBI) or active TB, unless in the context of a clinical trial **(AIII)**.
- Immune reconstitution inflammatory syndrome (IRIS) may occur after initiation of ART. Both ART and TB treatment should be continued while managing IRIS **(AIII)**.
- Treatment support, which can include directly observed therapy (DOT) of TB treatment, is strongly recommended for HIV-infected patients with active TB disease **(AII)**.

**Rating of Recommendations:** A = Strong; B = Moderate; C = Optional

**Rating of Evidence:** I = Data from randomized controlled trials; II = Data from well-designed nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion

### Treatment of Active Tuberculosis in HIV-Infected Patients

HIV infection significantly increases the risk of progression from latent to active TB disease. The CD4 cell count influences both the frequency and severity of active TB disease.<sup>1-2</sup> Active TB also negatively affects HIV disease. It may be associated with a higher HIV viral load and more rapid progression of HIV disease.<sup>3</sup>

Active pulmonary or extrapulmonary TB disease requires prompt initiation of TB treatment. The treatment of active TB disease in HIV-infected patients should follow the general principles guiding treatment for

individuals without HIV (**AI**). Treatment of drug-susceptible TB disease should include a standard regimen that consists of isoniazid (INH) + a rifamycin (rifampin or rifabutin) + pyrazinamide + ethambutol given for 2 months, followed by INH + a rifamycin for 4 to 7 months.<sup>4</sup> The [Guidelines for Prevention and Treatment of Opportunistic Infections in HIV-Infected Adults and Adolescents](#)<sup>4</sup> include a more complete discussion of the diagnosis and treatment of TB disease in HIV-infected patients.

All patients with HIV/TB disease should be treated with ART (**AI**). Important issues related to the use of ART in patients with active TB disease include: (1) when to start ART, (2) significant pharmacokinetic drug-drug interactions between rifamycins and some antiretroviral (ARV) agents, (3) the additive toxicities associated with concomitant ARV and TB drug use, (4) the development of TB-associated IRIS after ART initiation, and (5) the need for treatment support including DOT and the integration of HIV and TB care and treatment.

## Antiretroviral Therapy in Patients with Active Tuberculosis

### *Patients Diagnosed with Tuberculosis While Receiving Antiretroviral Therapy*

When TB is diagnosed in a patient receiving ART, the patient's ARV regimen should be assessed with particular attention to potential pharmacokinetic interactions with rifamycins (discussed below). The patient's regimen may need to be modified to permit use of the optimal TB treatment regimen (see [Tables 17–19](#) for dosing recommendations).

### *Patients Not Yet Receiving Antiretroviral Therapy*

Until recently, when to start ART in patients with active TB has been a subject of debate. Survival is improved when ART is started early following initiation of TB therapy, but a delay in initiating ART often was favored because of the potential complications of high pill burden, additive toxicities, drug interactions, adherence, and the potential for development of IRIS. Recent studies primarily conducted in resource-limited settings, including three randomized controlled trials, have helped clarify the question of when to start ART in patients with active TB.<sup>5–8</sup>

The SAPIt study conducted in South Africa convincingly demonstrated that starting ART during rather than after concluding treatment for TB can significantly reduce mortality. In this study, ambulatory HIV-infected patients with smear-positive TB and CD4 counts  $<500$  cells/mm<sup>3</sup> were randomized to one of three treatment arms: integrated therapy with ART initiated either during the first 4 weeks of TB therapy or after the first 8 weeks of TB treatment (i.e., during the continuation phase of TB therapy) or sequential therapy with ART initiated after the conclusion of standard TB therapy. The median CD4 cell count of participants at study entry was 150 cells/mm<sup>3</sup>. The sequential therapy arm was stopped when an early analysis demonstrated that the mortality rate in the combined two integrated arms was 56% lower than the rate in the sequential therapy arm. Treatment was continued in the two integrated arms until study completion.<sup>5</sup>

With the completion of SAPIt and 2 other randomized controlled trials, CAMELIA and STRIDE, the question on the optimal time to initiate ART during TB therapy has been addressed. Findings from these trials now serve as the basis for the Panel's recommendations on when to start ART in patients with active TB.

In the final analysis of the SAPIt trial, there were no differences in rates of AIDS or death between the 2 integrated arms of the study (patients who started ART within 4 weeks after initiating TB treatment vs. those who started ART at 8–12 weeks [i.e., within 4 weeks after completing the intensive phase of TB treatment]). However, in patients with baseline CD4 counts  $<50$  cells/mm<sup>3</sup> (17% of the study population), the rate of AIDS or death was lower in the earlier therapy group than in the later therapy group (8.5 vs. 26.3 cases per 100 person-years, a strong trend favoring the earlier treatment arm,  $P = 0.06$ ). For all patients, regardless of CD4

cell count, earlier therapy was associated with a higher incidence of IRIS and of adverse events that required a switch in ARV drugs than later therapy. Two deaths were attributed to IRIS.<sup>6</sup>

In the CAMELIA study, which was conducted in Cambodia<sup>7</sup>, patients who had CD4 counts  $<200$  cells/mm<sup>3</sup> were randomized to initiate ART at 2 weeks or 8 weeks after initiation of TB treatment. Study participants had advanced HIV disease, with a median entry CD4 count of 25 cells/mm<sup>3</sup>; low BMIs (median = 16.8 kg/m<sup>2</sup>), Karnofsky scores (87%  $<70$ ), and hemoglobin levels (median = 8.7 g/dl); and high rates of disseminated TB disease. Compared with therapy initiated at 8 weeks, ART initiated at 2 weeks resulted in a 38% reduction in mortality ( $P = 0.006$ ). A significant reduction in mortality was seen in patients with CD4 counts  $\leq 50$  cells/mm<sup>3</sup> and in patients with CD4 counts 51 to 200 cells/mm<sup>3</sup>. Overall, 6 deaths associated with TB-IRIS were reported.

The ACTG 5221 (STRIDE) trial, a multinational study conducted at 28 sites, randomized ART-naïve patients with confirmed or probable TB and CD4 counts  $<250$  cells/mm<sup>3</sup> to earlier ( $<2$  weeks) or later (8–12 weeks) ART.<sup>8</sup> At study entry, the participants' median CD4 count was 77 cells/mm<sup>3</sup>. The rates of mortality and AIDS diagnoses were not different between the earlier and later arms, although higher rates of IRIS were seen in the earlier arm. However, a significant reduction in AIDS or death was seen in the subset of patients with CD4 counts  $<50$  cells/mm<sup>3</sup> who were randomized to the earlier ART arm ( $P = 0.02$ ).

In each of these 3 studies, IRIS was more common in patients initiating ART earlier than in patients starting ART later, but the syndrome was infrequently associated with mortality. Collectively these 3 trials demonstrate that in patients with active TB and with very low CD4 cell counts (i.e.,  $<50$  cells/mm<sup>3</sup>), early initiation of ART can reduce mortality and AIDS progression, albeit at the risk of increased IRIS. These findings strongly favor initiation of ART within the first 2 weeks of TB treatment in patients with CD4 cell counts  $<50$  cells/mm<sup>3</sup> (**AI**).

The question of when to start ART in patients with CD4 counts  $\geq 50$  cells/mm<sup>3</sup> is also informed by these studies. The STRIDE and SAPIt studies—in which the patients with CD4 cell counts  $\geq 50$  cells/mm<sup>3</sup> were relatively healthy and with reasonable Karnofsky scores (note the SAPIt study excluded patients with Karnofsky scores  $<70$ ) and BMIs—demonstrated that ART initiation in these patients can be delayed until 8 to 12 weeks after initiation of TB therapy (**AI** for CD4 counts 51–500 cells/mm<sup>3</sup> and **BIII** for CD4 counts  $>500$  cells/mm<sup>3</sup>).

However, the CAMELIA study, which included more patients who were severely ill than the STRIDE and SAPIt studies, showed that early initiation of ART improved survival both in patients with CD4 counts  $\leq 50$  cells/mm<sup>3</sup> and in patients with CD4 counts from 51 to 200 cells/mm<sup>3</sup>. In a multivariate analysis, age  $>40$  years, low BMI ( $<16$ ), low Karnofsky score ( $<40$ ), elevated aspartate aminotransferase (AST) level ( $>1.25 \times$  the upper limit of normal [ULN]), disseminated and MDR TB were independently associated with poor survival; whereas in a univariate analysis, hemoglobin  $<10$ g/dl also was associated with poor survival.

Thus, recently published results from the three clinical trials are complementary in defining the need for ART and use of CD4 count and clinical status to inform decisions on the optimal time to initiate ART in patients with HIV and TB disease. Earlier initiation of ART within 2 to 4 weeks of TB treatment should be strongly considered for patients with CD4 cell counts from 50 to 200 cells/mm<sup>3</sup> who have evidence of clinical disease of major severity as indicated by clinical evaluation, low Karnofsky score, low BMI, low hemoglobin, low albumin, or organ system dysfunction (**BI**). Initiation of ART within 2 to 4 weeks also should be considered for patients with CD4 counts  $>200$  cells/mm<sup>3</sup> who present with evidence of severe disease (**BIII**).

Of additional importance, each of the above studies demonstrated excellent responses to ART, with 90% and  $>95\%$  of participants achieving suppressed viremia (HIV RNA  $<400$  copies/mL) at 12 months in the SAPIt and CAMELIA studies, respectively, and 74% of participants at 2 years in the STRIDE study.

Mortality rates in patients with MDR or XDR TB and HIV coinfection are very high.<sup>9</sup> Retrospective case control studies and case series provide growing evidence of better outcomes associated with receipt of ART in such coinfecting patients,<sup>10</sup> but the optimal timing for initiation of ART is unknown. However, given the high rates and rapid mortality, most experts recommend that ART be initiated within 2 to 4 weeks after confirmation of the diagnosis of drug resistance and initiation of second-line TB therapy (**BIII**).

All HIV-infected pregnant women with active TB should be started on ART as early as feasible, both for maternal health and to prevent perinatal transmission of HIV (**AIII**). The choice of ART should be based on efficacy and safety in pregnancy and take into account potential drug-drug interactions between ARVs and rifamycins (see [Perinatal Guidelines](#) for more detailed discussions).<sup>11</sup>

TB meningitis often is associated with severe complications and high mortality rate. In a randomized study conducted in Vietnam, patients were randomized to immediate ART or to therapy deferred until 2 months after initiation of TB treatment. A higher rate of severe (Grade 4) adverse events was seen in patients who received immediate ART than in those who deferred therapy (80.3% vs. 69.1%, respectively;  $P = 0.04$ ).<sup>12</sup> In this study 59.8% of the immediate ART patients and 55.5% of the delayed ART patients died within 9 months. However, in the United States, where patients may be more closely monitored and treated for severe adverse events such as central nervous system (CNS) IRIS, many experts feel that ART should be initiated as for other HIV/TB-coinfecting patients (**CIII**).

## Drug Interaction Considerations

A rifamycin is a crucial component in treatment of drug-sensitive TB. However, both rifampin and rifabutin are inducers of the hepatic cytochrome P (CYP) 450 and uridine diphosphate glucosyltransferase (UGT) 1A1 enzymes and are associated with significant interactions with most ARV agents including all PIs, non-nucleoside reverse transcriptase inhibitors (NNRTIs), maraviroc (MVC), and raltegravir (RAL). Rifampin is a potent enzyme inducer, leading to accelerated drug clearance and significant reduction in ARV drug exposure. Despite these interactions, some observational studies suggest that good virologic, immunologic, and clinical outcomes may be achieved with standard doses of efavirenz (EFV)<sup>13-14</sup> and, to a lesser extent, nevirapine (NVP)<sup>15-16</sup> when combined with rifampin. However, rifampin is not recommended in combination with all PIs and the NNRTIs etravirine (ETR) and rilpivirine (RPV). When rifampin is used with MVC or RAL, increased dosage of the ARV is generally recommended. Rifabutin, a weaker enzyme inducer, is an alternative to rifampin. Because rifabutin is a substrate of the CYP 450 enzyme system, its metabolism may be affected by the NNRTI or PI. [Tables 18, 19a, 19b, 19d, and 19e](#) outline the magnitude of these interactions and provide dosing recommendations when rifamycins and selected ARV drugs are used concomitantly. After determining the drugs and doses to use, clinicians should monitor patients closely to assure good control of both TB and HIV infections. Suboptimal HIV suppression or suboptimal response to TB treatment should prompt assessment of drug adherence, subtherapeutic drug levels (consider therapeutic drug monitoring [TDM]), and acquired drug resistance.

Rifapentine is a long-acting rifamycin that can be given once weekly with INH for the treatment of active or latent TB infection. Similar to rifampin and rifabutin, rifapentine is also a CYP3A4 inducer. No systematic study has been performed to assess the magnitude of the enzyme induction effect of rifapentine on the metabolism of ARV drugs and other concomitant drugs. Significant enzyme induction can result in reduced ARV drug exposure, which may compromise virologic efficacy. Rifapentine is **not recommended** for treatment of latent or active TB infection in patients receiving ART, unless given in the context of a clinical trial (**AIII**).

## Anti-Tuberculosis/Antiretroviral Drug Toxicities

ARV agents and TB drugs, particularly INH, rifamycin, and pyrazinamide, can cause drug-induced hepatitis. These first-line TB drugs should be used for treatment of active TB disease, even with coadministration of other potentially hepatotoxic drugs or when baseline liver disease is present (**AIII**). Patients receiving potentially hepatotoxic drugs should be monitored frequently for clinical symptoms and signs of hepatitis and have laboratory monitoring for hepatotoxicity. Peripheral neuropathy can occur with administration of INH, didanosine (ddI), or stavudine (d4T) or may be a manifestation of HIV infection. All patients receiving INH also should receive supplemental pyridoxine to reduce peripheral neuropathy. Patients should be monitored closely for signs of drug-related toxicities and receive alternative ARVs to ddI or d4T.

## Immune Reconstitution Inflammatory Syndrome with Tuberculosis and Antiretroviral Agents

IRIS occurs in two forms: unmasking and paradoxical. The mechanism of the syndrome is the same for both forms: restoration of immune competence by administration of ART, resulting in an exuberant host response to TB bacilli and/or antigens. Unmasking IRIS refers to the initial clinical manifestations of active TB that occurs soon after ART is started. Paradoxical IRIS refers to the worsening of TB clinical symptoms after ART is started in patients who are receiving TB treatment. Severity of IRIS ranges from mild to severe to life threatening. IRIS has been reported in 8% to more than 40% of patients starting ART after TB is diagnosed, although the incidence depends on the definition of IRIS and the intensity of monitoring.<sup>17-18</sup>

Predictors of IRIS include CD4 count <50 cells/mm<sup>3</sup>; higher on-ART CD4 counts; high pre-ART and lower on-ART HIV viral loads; severity of TB disease, especially high pathogen burden; and less than 30-day interval between initiation of TB and HIV treatments.<sup>19-22</sup> Most IRIS in HIV/TB disease occurs within 3 months of the start of TB treatment. Delaying initiation of ART for 2 to 8 weeks may reduce the incidence and severity of IRIS. However, this possible advantage of delayed ART must be weighed against the potential benefit of earlier ART in improving immune function and preventing progression of HIV disease and mortality.

Patients with mild or moderately severe IRIS can be managed symptomatically or treated with nonsteroidal anti-inflammatory agents. Patients with more severe IRIS can be treated successfully with corticosteroids. A recent randomized, placebo-controlled trial demonstrated benefit of corticosteroids in the management of IRIS symptoms (as measured by decreasing days of hospitalization and Karnofsky performance score) without adverse consequences.<sup>23</sup> In the presence of IRIS, neither TB therapy nor ART should be stopped because both therapies are necessary for the long-term health of the patient (**AIII**).

### ***Immune Reconstitution with Antiretroviral Therapy: Conversion to Positive Tuberculin Skin Test and Interferon-Gamma Release Assay***

Immune reconstitution with ART may result in unmasking LTBI (i.e., conversion of a previously negative tuberculin skin test [TST] to a positive TST or a positive interferon-gamma [IFN- $\gamma$ ] release assay [IGRA] for *Mycobacterium tuberculosis*-specific proteins). A positive IGRA, similar to a positive TST, is indicative of LTBI in the absence of evidence of active TB disease.<sup>24</sup> Because treatment for LTBI is indicated in the absence of evidence of active TB disease, clinicians should be aware of this phenomenon. Patients with a negative TST or IGRA and advanced HIV disease (i.e., CD4 count <200 cells/mm<sup>3</sup>) should have a repeat TST or IGRA after initiation of ART and CD4 count increase to >200 cells/mm<sup>3</sup> (**BII**).<sup>25</sup>



## Caring for Patients with HIV and Tuberculosis

Close collaboration among clinicians, health care institutions, and public health programs involved in the diagnosis and treatment of HIV-infected patients with active TB disease is necessary in order to integrate care and improve medication adherence and TB treatment completion rates, reduce drug toxicities, and maximize HIV outcomes. HIV-infected patients with active TB disease should receive treatment support, including adherence counseling and DOT, corresponding to their needs **(AII)**. ART simplification or use of coformulated fixed-dose combinations also may help to improve drug adherence.

## References

1. Jones BE, Young SM, Antoniskis D, Davidson PT, Kramer F, Barnes PF. Relationship of the manifestations of tuberculosis to CD4 cell counts in patients with human immunodeficiency virus infection. *Am Rev Respir Dis*. Nov 1993;148(5):1292-1297.
2. Perlman DC, el-Sadr WM, Nelson ET, et al. Variation of chest radiographic patterns in pulmonary tuberculosis by degree of human immunodeficiency virus-related immunosuppression. The Terry Bein Community Programs for Clinical Research on AIDS (CPCRA). The AIDS Clinical Trials Group (ACTG). *Clin Infect Dis*. Aug 1997;25(2):242-246.
3. Whalen C, Horsburgh CR, Hom D, Lahart C, Simberkoff M, Ellner J. Accelerated course of human immunodeficiency virus infection after tuberculosis. *Am J Respir Crit Care Med*. Jan 1995;151(1):129-135.
4. Panel on Opportunistic Infections in HIV-Infected Adults and Adolescents. Guidelines for the prevention and treatment of opportunistic infections in HIV-infected adults and adolescents: recommendations from the Centers for Disease Control and Prevention, the National Institutes of Health, and the HIV Medicine Association of the Infectious Diseases Society of America. Available at [http://aidsinfo.nih.gov/contentfiles/lvguidelines/adult\\_oi.pdf](http://aidsinfo.nih.gov/contentfiles/lvguidelines/adult_oi.pdf). Accessed January 6, 2014.
5. Abdool Karim SS, Naidoo K, Grobler A, et al. Timing of initiation of antiretroviral drugs during tuberculosis therapy. *N Engl J Med*. Feb 25 2010;362(8):697-706.
6. Abdool Karim SS, Naidoo K, Grobler A, et al. Integration of antiretroviral therapy with tuberculosis treatment. *N Engl J Med*. Oct 20 2011;365(16):1492-1501.
7. Blanc FX, Sok T, Laureillard D, et al. Earlier versus later start of antiretroviral therapy in HIV-infected adults with tuberculosis. *N Engl J Med*. Oct 20 2011;365(16):1471-1481.
8. Havlir DV, Kendall MA, Ive P, et al. Timing of antiretroviral therapy for HIV-1 infection and tuberculosis. *N Engl J Med*. Oct 20 2011;365(16):1482-1491.
9. Gandhi NR, Shah NS, Andrews JR, et al. HIV coinfection in multidrug- and extensively drug-resistant tuberculosis results in high early mortality. *Am J Respir Crit Care Med*. Jan 1 2010;181(1):80-86.
10. Dheda K, Shean K, Zumla A, et al. Early treatment outcomes and HIV status of patients with extensively drug-resistant tuberculosis in South Africa: a retrospective cohort study. *Lancet*. May 22 2010;375(9728):1798-1807.
11. Panel on Treatment of HIV-Infected Pregnant Women and Prevention of Perinatal Transmission. Recommendations for Use of Antiretroviral Drugs in Pregnant HIV-1-Infected Women for Maternal Health and Interventions to Reduce Perinatal HIV Transmission in the United States. Available at <http://aidsinfo.nih.gov/contentfiles/PerinatalGL.pdf>.
12. Torok ME, Yen NT, Chau TT, et al. Timing of initiation of antiretroviral therapy in human immunodeficiency virus (HIV)—associated tuberculous meningitis. *Clin Infect Dis*. Jun 2011;52(11):1374-1383.
13. Friedland G, Khoo S, Jack C, Lalloo U. Administration of efavirenz (600 mg/day) with rifampicin results in highly variable levels but excellent clinical outcomes in patients treated for tuberculosis and HIV. *J Antimicrob Chemother*. Dec 2006;58(6):1299-1302.
14. Manosuthi W, Kiertiburanakul S, Sungkanuparph S, et al. Efavirenz 600 mg/day versus efavirenz 800 mg/day in HIV-infected patients with tuberculosis receiving rifampicin: 48 weeks results. *AIDS*. Jan 2 2006;20(1):131-132.
15. Moses M, Zachariah R, Tayler-Smith K, et al. Outcomes and safety of concomitant nevirapine and rifampicin treatment under programme conditions in Malawi. *Int J Tuberc Lung Dis*. Feb 2010;14(2):197-202.
16. Shipton LK, Wester CW, Stock S, et al. Safety and efficacy of nevirapine- and efavirenz-based antiretroviral treatment in adults treated for TB-HIV co-infection in Botswana. *Int J Tuberc Lung Dis*. Mar 2009;13(3):360-366.
17. Haddow LJ, Moosa MY, Easterbrook PJ. Validation of a published case definition for tuberculosis-associated immune reconstitution inflammatory syndrome. *AIDS*. Jan 2 2010;24(1):103-108.

18. Meintjes G, Lawn SD, Scano F, et al. Tuberculosis-associated immune reconstitution inflammatory syndrome: case definitions for use in resource-limited settings. *Lancet Infect Dis*. Aug 2008;8(8):516-523.
19. Manosuthi W, Kiertiburanakul S, Phoorisri T, Sungkanuparph S. Immune reconstitution inflammatory syndrome of tuberculosis among HIV-infected patients receiving antituberculous and antiretroviral therapy. *J Infect*. Dec 2006;53(6):357-363.
20. Colebunders R, John L, Huyst V, Kambugu A, Scano F, Lynen L. Tuberculosis immune reconstitution inflammatory syndrome in countries with limited resources. *Int J Tuberc Lung Dis*. Sep 2006;10(9):946-953.
21. Michailidis C, Pozniak AL, Mandalia S, Basnayake S, Nelson MR, Gazzard BG. Clinical characteristics of IRIS syndrome in patients with HIV and tuberculosis. *Antivir Ther*. 2005;10(3):417-422.
22. Lawn SD, Myer L, Bekker LG, Wood R. Tuberculosis-associated immune reconstitution disease: incidence, risk factors and impact in an antiretroviral treatment service in South Africa. *AIDS*. Jan 30 2007;21(3):335-341.
23. Meintjes G, R. J. Wilkinson, et al. (2010). Randomized placebo-controlled trial of prednisone for paradoxical tuberculosis-associated immune reconstitution inflammatory syndrome. *AIDS* 24(15): 2381-2390.
24. Menzies D, Pai M, Comstock G. Meta-analysis: new tests for the diagnosis of latent tuberculosis infection: areas of uncertainty and recommendations for research. *Ann Intern Med*. Mar 6 2007;146(5):340-354.
25. Girardi E, Palmieri F, Zaccarelli M, et al. High incidence of tuberculin skin test conversion among HIV-infected individuals who have a favourable immunological response to highly active antiretroviral therapy. *AIDS*. Sep 27 2002;16(14):1976-1979.

## Limitations to Treatment Safety and Efficacy

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### Adherence to Antiretroviral Therapy (Last updated May 1, 2014; last reviewed May 1, 2014)

Strict adherence to antiretroviral therapy (ART) is key to sustained HIV suppression, reduced risk of drug resistance, improved overall health, quality of life, and survival,<sup>1,2</sup> as well as decreased risk of HIV transmission.<sup>3</sup> Conversely, poor adherence is the major cause of therapeutic failure. Achieving adherence to ART is a critical determinant of long-term outcome in HIV infected patients. For many chronic diseases, such as diabetes or hypertension, drug regimens remain effective even after treatment is resumed following a period of interruption. In the case of HIV infection, however, loss of virologic control as a consequence of non-adherence to ART may lead to emergence of drug resistance and loss of future treatment options. Many patients initiating ART or already on therapy are able to maintain consistent levels of adherence with resultant viral suppression, CD4+ T-lymphocyte (CD4) count recovery, and improved clinical outcomes. Others, however, have poor adherence from the outset of ART and/or experience periodic lapses in adherence over the lifelong course of treatment. Identifying those with adherence-related challenges that require attention and implementing appropriate strategies to enhance adherence are essential roles for all members of the treatment team.

Recent data underscore the importance of conceptualizing treatment adherence broadly to include early engagement in care and sustained retention in care. The concept of an HIV “treatment cascade” has been used to describe the process of HIV testing, linkage to care, initiation of effective ART, adherence to treatment, and retention in care. The U.S. Centers for Disease Control and Prevention estimates that only 36% of the people living with HIV in the United States are prescribed ART and that among these individuals, only 76% have suppressed viral loads.<sup>4</sup> Thus, to achieve optimal clinical outcomes and to realize the potential public health benefit of treatment as prevention, attention to each step in the treatment cascade is critical.<sup>5</sup> Therefore, provider skill and involvement to retain patients in care and help them achieve high levels of medication adherence are crucial.

This section provides updated guidance on assessing and monitoring adherence and outlines strategies to help patients maintain high levels of adherence.

### *Factors Associated with Adherence Success and Failure*

Adherence to ART can be influenced by a number of factors, including the patient’s social situation and clinical condition; the prescribed regimen; and the patient-provider relationship.<sup>6</sup> It is critical that each patient receives and understands information about HIV disease including the goals of therapy (achieving and maintaining viral suppression, decreasing HIV-associated morbidity and mortality, and preventing sexual transmission of HIV), the prescribed regimen (including dosing schedule and potential side effects), the importance of strict adherence to ART, and the potential for the development of drug resistance as a consequence of suboptimal adherence. However, information alone is not sufficient to assure high levels of adherence; patients must also be positively motivated to initiate and maintain therapy.

From a patient perspective, nonadherence is often a consequence of one or more behavioral, structural, and psychosocial barriers (e.g., depression and other mental illnesses, neurocognitive impairment, low health literacy, low levels of social support, stressful life events, high levels of alcohol consumption and active substance use, homelessness, poverty, nondisclosure of HIV serostatus, denial, stigma, and inconsistent access to medications).<sup>7-9</sup> Furthermore, patient age may affect adherence. For example, some adolescent and young adult HIV patients, in particular, have substantial challenges in achieving levels of adherence necessary for successful therapeutic outcomes (see [HIV-Infected Adolescents](#) section).<sup>10,11</sup> In addition, failure to adopt practices that facilitate adherence, such as linking medication taking to daily activities or using a medication reminder system or a pill organizer, is also associated with treatment failure.<sup>12</sup>

Characteristics of one or more components of the prescribed regimen can affect adherence. Simple, once-daily regimens,<sup>13</sup> including those with low pill burden, without a food requirement, and few side effects or toxicities, are associated with higher levels of adherence.<sup>14,15</sup> Many currently available ARV regimens are much easier to take and better tolerated than older regimens. Studies have shown that patients taking once-daily regimens have higher rates of adherence than those taking twice-daily dosing regimens.<sup>15</sup> However, data to support or refute the superiority of fixed-dose combination product of 1-pill versus 3-pills (of individual drug products), once-daily regimens—as might be required for the use of some soon-to-be-available generic-based ARV regimens—are limited.

Characteristics of the clinical setting can also have important structural influences on the success or failure of medication adherence. Settings that provide comprehensive multidisciplinary care (e.g., with case managers, pharmacists, social workers, psychiatric care providers) are often more successful in supporting patients' complex needs, including their medication adherence-related needs. Further, specific settings, such as prisons and other institutional settings, may thwart or support medication adherence. Drug abuse treatment programs are often best suited to address substance use that may confound adherence and may offer services, such as directly observed therapy, that promote adherence.

Finally, a patient-provider relationship that enhances patient trust through non-judgmental and supportive care and use of motivational strategies can positively influence medication adherence.

### ***Routine Monitoring of Adherence and Retention in Care***

Although there is no gold standard for assessing adherence,<sup>1</sup> properly implemented validated tools and assessment strategies can prove valuable in most clinical settings. Viral load suppression is one of the most reliable indicators of adherence and can be used as positive reinforcement to encourage continuous adherence. When patients initiating ART fail to achieve viral suppression by 24 weeks of treatment, the possibility of suboptimal adherence and other factors must be assessed. Similarly, treatment failure as measured by detectable viral load during chronic care is most likely the result of non-adherence. Patient self-report, the most frequently used method for evaluating medication adherence, remains a useful tool for assessing adherence over time. However, self-reports must be properly and carefully assessed as patients may overestimate adherence. While carefully assessed patient self report of high-level adherence to ART has been associated with favorable viral load responses,<sup>16,17</sup> patient admission of suboptimal adherence is highly correlated with poor therapeutic response. The reliability of self report often depends on how the clinician elicits the information. It is most reliable when ascertained in a simple, nonjudgmental, routine, and structured format that normalizes less-than-perfect adherence and minimizes socially desirable or “white coat adherence” responses. Some patients may selectively adhere to components of a regimen believed to have the fewest side effects or the lowest dosing frequency or pill burden. To allow patients to more accurately disclose lapses in adherence, some experts suggest that providers inquire about the number of missed doses during a defined time period rather than directly asking “Are you taking your medicines?” Others advocate simply asking patients to rate their adherence during the last 4 weeks on a 5- or 6-point Likert scale.<sup>18,19</sup> Regardless of how obtained, patient self-report, in contrast to other measures of adherence, allows for immediate patient-provider discussion to identify reasons for missed doses and to explore corrective strategies.

Other measures of adherence include pharmacy records and pill counts. Pharmacy records can be valuable when medications are obtained exclusively from a single source so that refills can be traced. Pill counts are commonly used but can be altered by patients. Other methods of assessing adherence include the use of therapeutic drug monitoring and electronic measurement devices (e.g., MEMS bottle caps and dispensing systems). However, these methods are costly and are usually done primarily in research settings.

### ***Interventions to Improve Adherence and Retention in Care***

A continuum of ART adherence support services is necessary to meet individual patient needs. All health care

team members, including physicians, physician assistants, nurse practitioners, nurse midwives, nurses, pharmacists, medication managers, and social workers play integral roles in successful adherence programs.<sup>17,20-22</sup>

Effective adherence interventions vary in modality and duration, and by clinical setting, provider, and patient. There are many options that can be customized to suit a range of needs and settings (see [Table 13](#)). An increasing number of interventions have proven effective in improving adherence to ART. For descriptions of the interventions, see: <http://www.cdc.gov/hiv/topics/research/prs/ma-good-evidence-interventions.htm>.<sup>23</sup>

Clinicians should provide all patients with a basic level of adherence-related information and support. Before writing the first prescription(s) for patients initiating or reinitiating ART, clinicians should assess the patient's adherence readiness. Clinicians should evaluate patients' knowledge about HIV disease, treatment, and prevention and provide basic information about ART, viral load and CD4 count and the expected outcome of ART based on these parameters, the importance of strict adherence to ART, and the consequences of non-adherence. In addition, clinicians should assess patients' motivation to successfully adhere to ART and identify and support facilitating factors and address potential barriers to adherence. Finally, clinicians should be assured that patients have the necessary medication taking skills to follow the regimen as prescribed.

Given the wide array of treatment options, individualizing treatment with patient involvement in decision making is the cornerstone of treatment planning and therapeutic success. The first principle of successful treatment is to design an understandable plan to which the patient can commit.<sup>24,25</sup> It is important to consider the patient's daily schedule; patient tolerance of pill number, size and frequency; and any issues affecting absorption (e.g., use of acid reducing therapy and food requirements). With the patient's input, a medication choice and administration schedule should be tailored to his/her routine daily activities. If necessary, soliciting help from family members may also improve adherence. Patients who are naive to ART should understand that their first regimen usually offers the best chance for taking a simple regimen that affords long-term treatment success and prevention of drug resistance. Establishing a trusting patient-provider relationship over time and maintaining good communication will help to improve adherence and long-term outcomes. Medication taking can also be enhanced by the use of pill organizers and medication reminder aids (e.g., alarm clock, pager, calendar).

Positive reinforcement can greatly help patients maintain high levels of adherence. This technique to foster adherence includes informing patients of their low or suppressed HIV viral load levels and increases in CD4 cell counts. Motivational interviewing has also been used with some successes. Recognizing high levels of adherence with incentives and rewards can facilitate treatment success in some patients. Adherence-contingent reward incentives such as meal tickets, grocery bags, lotto tickets, and cash have been used in the treatment of HIV and other chronic diseases. The effectiveness of using cash incentives to promote HIV testing, entry to care, and adherence to ART is currently being studied in the multi-site HPTN 065 trial. Other effective interventions include nurse home visits, a five-session group intervention, pager messaging, and couples or family-based interventions. To maintain high levels of adherence in some patients, it is critically important to provide substance abuse therapy and to strengthen social support. Directly observed therapy (DOT) has been effective in providing ART to active drug users<sup>26</sup> but not to patients in a general clinic population.<sup>27</sup>

To determine whether additional adherence or retention interventions are warranted, assessments should be done at each clinical encounter and should be the responsibility of the entire health care team. Routine monitoring of HIV viral load, pharmacy records, and indicators that measure retention in care are useful to determine if more intense efforts are needed to improve adherence. Patients with a history of non-adherence to ART are at risk for poor adherence when re-starting therapy with the same or new drugs. Special attention should be given to identify and address any reason for previous poor adherence. Preferential use of ritonavir-boosted protease inhibitor-(PI/r)-based ART, which has a higher barrier to the development of resistance than



other treatment options, should be considered if poor adherence is predicted.

The critical elements of adherence go hand in hand with linkage-to-care and retention in care. A recently released guideline provides a number of strategies to improve entry and retention in care and adherence to therapy for HIV infected patients.<sup>5</sup> As with adherence monitoring, research advances offer many options for systematic monitoring of retention in care that may be used in accordance with local resources and standards. The options include surveillance of visit adherence, gaps in care, and the number of visits during a specified period of time.<sup>28</sup>

## Conclusion

Adherence to ART is central to therapeutic success. Given the many available assessment strategies and interventions, the challenge for the treatment team is to select the techniques that best fit each patient and patient population, and, according to available resources, the treatment setting. In addition to maintaining high levels of medication adherence, attention to effective linkage to care, engagement in care, and retention in care is critical for successful treatment outcomes. To foster treatment success, there are interventions to support each step in the cascade of care, as well as guidance on systematic monitoring of each step in the cascade.<sup>5</sup>

**Table 13. Strategies to Improve Adherence to Antiretroviral Therapy and Retention in Care**  
(page 1 of 3)

Strategies	Examples
Use a multidisciplinary team approach. Provide an accessible, trustworthy health care team.	<ul style="list-style-type: none"> <li>• Nonjudgmental providers, nurses, social workers, pharmacists, and medication managers</li> </ul>
Strengthen early linkage to care and retention in care.	<ul style="list-style-type: none"> <li>• Encourage healthcare team participation in linkage to and retention in care.</li> </ul>
Assess patient readiness to start ART.	
Evaluate patient's knowledge about HIV disease, prevention and treatment and, on the basis of the assessment, provide HIV-related information.	<ul style="list-style-type: none"> <li>• Considering the patient's current knowledge base, provide information about HIV, including the natural history of the disease, HIV viral load and CD4 count and expected clinical outcomes according to these parameters, and therapeutic and prevention consequences of non-adherence.</li> </ul>
Identify facilitators, potential barriers to adherence, and necessary medication management skills before starting ART medication.	<ul style="list-style-type: none"> <li>• Assess patient's cognitive competence and impairment.</li> <li>• Assess behavioral and psychosocial challenges including depression, mental illnesses, levels of social support, high levels of alcohol consumption and active substance use, non-disclosure of HIV serostatus and stigma.</li> <li>• Identify and address language and literacy barriers.</li> <li>• Assess beliefs, perceptions, and expectations about taking ART (e.g., impact on health, side effects, disclosure issues, consequences of non-adherence).</li> <li>• Ask about medication taking skills and foreseeable challenges with adherence (e.g., past difficulty keeping appointments, adverse effects from previous medications, issues managing other chronic medications, need for medication reminders and organizers).</li> <li>• Assess structural issues including unstable housing, lack of income, unpredictable daily schedule, lack of prescription drug coverage, lack of continuous access to medications.</li> </ul>
Provide needed resources.	<ul style="list-style-type: none"> <li>• Provide or refer for mental health and/or substance abuse treatment.</li> <li>• Provide resources to obtain prescription drug coverage, stable housing, social support, and income and food security.</li> </ul>

**Table 13. Strategies to Improve Adherence to Antiretroviral Therapy and Retention in Care**  
(page 2 of 3)

Strategies	Examples
Involve the patient in ARV regimen selection.	<ul style="list-style-type: none"> <li>• Review regimen potency, potential side effects, dosing frequency, pill burden, storage requirements, food requirements, and consequences of nonadherence.</li> <li>• Assess daily activities and tailor regimen to predictable and routine daily events.</li> <li>• Consider preferential use of PI/r-based ART if poor adherence is predicted.</li> <li>• Consider use of fixed-dose combination formulation.</li> <li>• Assess if cost/co-payment for drugs can affect access to medications and adherence.</li> </ul>
Assess adherence at every clinic visit.	<ul style="list-style-type: none"> <li>• Monitor viral load as a strong biologic measure of adherence.</li> <li>• Use a simple behavioral rating scale.</li> <li>• Employ a structured format that normalizes or assumes less-than-perfect adherence and minimizes socially desirable or “white coat adherence” responses.</li> <li>• Ensure that other members of the health care team also assess adherence.</li> </ul>
Use positive reinforcement to foster adherence success.	<ul style="list-style-type: none"> <li>• Inform patients of low or non-detectable levels of HIV viral load and increases in CD4 cell counts.</li> <li>• When needed, consider providing incentives and rewards for achieving high levels of adherence and treatment success.</li> </ul>
Identify the type of and reasons for nonadherence.	<ul style="list-style-type: none"> <li>• Failure to fill the prescription(s)</li> <li>• Failure to understand dosing instructions</li> <li>• Complexity of regimen (e.g., pill burden, size, dosing schedule, food requirements)</li> <li>• Pill aversion</li> <li>• Pill fatigue</li> <li>• Adverse effects</li> <li>• Inadequate understanding of drug resistance and its relationship to adherence</li> <li>• Cost-related issues</li> <li>• Depression, drug and alcohol use, homelessness, poverty</li> <li>• Stigma</li> <li>• Non-disclosure</li> <li>• Other potential barriers</li> </ul>
Select from among available effective treatment adherence interventions.	<ul style="list-style-type: none"> <li>• See <a href="http://www.cdc.gov/hiv/topics/research/prs/ma-good-evidence-interventions.htm">http://www.cdc.gov/hiv/topics/research/prs/ma-good-evidence-interventions.htm</a>.</li> <li>• Use adherence-related tools to complement education and counseling interventions (e.g., pill boxes, dose planners, reminder devices).</li> <li>• Use community resources to support adherence (e.g., visiting nurses, community workers, family, peer advocates).</li> <li>• Use patient prescription assistance programs.</li> <li>• Use motivational interviews.</li> </ul>

**Table 13. Strategies to Improve Adherence to Antiretroviral Therapy and Retention in Care**  
(page 3 of 3)

Strategies	Examples
Systematically monitor retention in care.	<ul style="list-style-type: none"> <li>Record and follow up on missed visits.</li> </ul>
On the basis of any problems identified through systematic monitoring, consider options to enhance retention in care given resources available.	<ul style="list-style-type: none"> <li>Provide outreach for those patients who drop out of care.</li> <li>Use peer or paraprofessional treatment navigators.</li> <li>Employ incentives to encourage clinic attendance or recognize positive clinical outcomes resulting from good adherence.</li> <li>Arrange for directly observed therapy (if feasible).</li> </ul>

**Key to Acronyms:** ART = antiretroviral therapy; CD4 = CD4 T lymphocyte; PI = protease inhibitor; PI/r = ritonavir-boosted protease inhibitor

## References

- Chesney MA. The elusive gold standard. Future perspectives for HIV adherence assessment and intervention. *J Acquir Immune Defic Syndr*. 2006;43 Suppl 1:S149-155. Available at <http://www.ncbi.nlm.nih.gov/pubmed/17133199>.
- World Health Organization (WHO). Adherence to long term therapies—evidence for action. 2003. Available at [http://www.who.int/chp/knowledge/publications/adherence\\_full\\_report.pdf](http://www.who.int/chp/knowledge/publications/adherence_full_report.pdf).
- Cohen MS, Chen YQ, McCauley M, et al. Prevention of HIV-1 infection with early antiretroviral therapy. *N Engl J Med*. 2011;365(6):493-505. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21767103>.
- Centers for Disease Control and Prevention. *Linkage to and retention in HIV Medical Care*. 2012. Available at <http://www.cdc.gov/hiv/prevention/programs/pwp/linkage.html>. Accessed on January 20, 2014.
- Thompson MA, Mugavero MJ, Amico KR, et al. Guidelines for improving entry into and retention in care and antiretroviral adherence for persons with HIV: evidence-based recommendations from an International Association of Physicians in AIDS Care panel. *Ann Intern Med*. 2012;156(11):817-833. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22393036>.
- Schneider J, Kaplan SH, Greenfield S, Li W, Wilson IB. Better physician-patient relationships are associated with higher reported adherence to antiretroviral therapy in patients with HIV infection. *J Gen Intern Med*. 2004;19(11):1096-1103. Available at <http://www.ncbi.nlm.nih.gov/pubmed/15566438>.
- Halkitis PN, Shrem MT, Zade DD, Wilton L. The physical, emotional and interpersonal impact of HAART: exploring the realities of HIV seropositive individuals on combination therapy. *J Health Psychol*. 2005;10(3):345-358. Available at <http://www.ncbi.nlm.nih.gov/pubmed/15857867>.
- Stirratt MJ, Remien RH, Smith A, et al. The role of HIV serostatus disclosure in antiretroviral medication adherence. *AIDS Behav*. 2006;10(5):483-493. Available at <http://www.ncbi.nlm.nih.gov/pubmed/16721505>.
- Carr RL, Gramling LF. Stigma: a health barrier for women with HIV/AIDS. *J Assoc Nurses AIDS Care*. 2004;15(5):30-39. Available at <http://www.ncbi.nlm.nih.gov/pubmed/15358923>.
- Ryscavage P, Anderson EJ, Sutton SH, Reddy S, Taiwo B. Clinical outcomes of adolescents and young adults in adult HIV care. *J Acquir Immune Defic Syndr*. 2011;58(2):193-197. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21826014>.
- Rudy BJ, Murphy DA, Harris DR, Muenz L, Ellen J, Adolescent Trials Network for HIVAI. Patient-related risks for nonadherence to antiretroviral therapy among HIV-infected youth in the United States: a study of prevalence and interactions. *AIDS Patient Care STDS*. 2009;23(3):185-194. Available at <http://www.ncbi.nlm.nih.gov/pubmed/19866536>.
- Fisher JD, Fisher WA, Amico KR, Harman JJ. An information-motivation-behavioral skills model of adherence to antiretroviral therapy. *Health Psychol*. 2006;25(4):462-473. Available at <http://www.ncbi.nlm.nih.gov/pubmed/16846321>.
- Parienti JJ, Bangsberg DR, Verdon R, Gardner EM. Better adherence with once-daily antiretroviral regimens: a meta-analysis. *Clin Infect Dis*. 2009;48(4):484-488. Available at <http://www.ncbi.nlm.nih.gov/pubmed/19140758>.
- Raboud J, Li M, Walmsley S, et al. Once daily dosing improves adherence to antiretroviral therapy. *AIDS Behav*. 2011;15(7):1397-1409. Available at <http://www.ncbi.nlm.nih.gov/pubmed/20878227>.
- Nachea JB, Parienti JJ, Uthman OA, et al. Lower Pill Burden and Once-daily Dosing Antiretroviral Treatment Regimens for HIV Infection: A Meta-Analysis of Randomized Controlled Trials. *Clin Infect Dis*. 2014. Available at

<http://www.ncbi.nlm.nih.gov/pubmed/24457345>.

16. Simoni JM, Kurth AE, Pearson CR, Pantalone DW, Merrill JO, Frick PA. Self-report measures of antiretroviral therapy adherence: A review with recommendations for HIV research and clinical management. *AIDS Behav.* 2006;10(3):227-245. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=16783535](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16783535).
17. Mannheimer SB, Morse E, Matts JP, et al. Sustained benefit from a long-term antiretroviral adherence intervention. Results of a large randomized clinical trial. *J Acquir Immune Defic Syndr.* 2006;43 Suppl 1:S41-47. Available at <http://www.ncbi.nlm.nih.gov/pubmed/17091022>.
18. Feldman BJ, Fredericksen RJ, Crane PK, et al. Evaluation of the single-item self-rating adherence scale for use in routine clinical care of people living with HIV. *AIDS Behav.* 2013;17(1):307-318. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23108721>.
19. Lu M, Safren SA, Skolnik PR, et al. Optimal recall period and response task for self-reported HIV medication adherence. *AIDS Behav.* 2008;12(1):86-94. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17577653](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17577653).
20. McPherson-Baker S, Malow RM, Penedo F, Jones DL, Schneiderman N, Klimas NG. Enhancing adherence to combination antiretroviral therapy in non-adherent HIV-positive men. *AIDS Care.* 2000;12(4):399-404. Available at <http://www.ncbi.nlm.nih.gov/pubmed/11091772>.
21. Kalichman SC, Cherry J, Cain D. Nurse-delivered antiretroviral treatment adherence intervention for people with low literacy skills and living with HIV/AIDS. *J Assoc Nurses AIDS Care.* 2005;16(5):3-15. Available at <http://www.ncbi.nlm.nih.gov/pubmed/16433105>.
22. Remien RH, Stirratt MJ, Dognin J, Day E, El-Bassel N, Warne P. Moving from theory to research to practice. Implementing an effective dyadic intervention to improve antiretroviral adherence for clinic patients. *J Acquir Immune Defic Syndr.* 2006;43 Suppl 1:S69-78. Available at <http://www.ncbi.nlm.nih.gov/pubmed/17133206>.
23. Centers for Disease Control and Prevention. Compendium of Evidence-Based HIV Behavioral Interventions: Medication Adherence Chapter. 2011. Available at <http://www.cdc.gov/hiv/topics/research/prs/ma-chapter.htm>.
24. Williams A, Friedland G. Adherence, compliance, and HAART. *AIDS Clin Care.* 1997;9(7):51-54, 58. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list\\_uids=11364415&dopt=Abstract](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uids=11364415&dopt=Abstract).
25. Vermeire E, Hearnshaw H, Van Royen P, Denekens J. Patient adherence to treatment: three decades of research. A comprehensive review. *J Clin Pharm Ther.* 2001;26(5):331-342. Available at <http://www.ncbi.nlm.nih.gov/pubmed/11679023>.
26. Altice FL, Maru DS, Bruce RD, Springer SA, Friedland GH. Superiority of directly administered antiretroviral therapy over self-administered therapy among HIV-infected drug users: a prospective, randomized, controlled trial. *Clin Infect Dis.* 2007;45(6):770-778. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17712763](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17712763).
27. Berg KM, Litwin AH, Li X, Heo M, Arnsten JH. Lack of sustained improvement in adherence or viral load following a directly observed antiretroviral therapy intervention. *Clin Infect Dis.* 2011;53(9):936-943. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21890753>.
28. Mugavero MJ, Davila JA, Nevin CR, Giordano TP. From access to engagement: measuring retention in outpatient HIV clinical care. *AIDS Patient Care STDS.* 2010;24(10):607-613. Available at <http://www.ncbi.nlm.nih.gov/pubmed/20858055>.

## Adverse Effects of Antiretroviral Agents (Last updated April 8, 2015; last reviewed April 8, 2015)

Adverse effects have been reported with the use of all antiretroviral (ARV) drugs and are among the most common reasons cited for switching or discontinuing therapy and for medication non-adherence.<sup>1</sup>

Fortunately, newer ARV regimens are less toxic than regimens used in the past. Generally less than 10% of antiretroviral therapy (ART)-naïve patients enrolled in randomized trials have treatment-limiting adverse events. However, because most clinical trials have a relatively short follow-up duration, the longer term complications of ART can be underestimated. In the Swiss Cohort study during a median of 6 years of follow-up, the presence of laboratory adverse events probably or certainly related to ART was associated with higher rates of mortality, which highlights the importance of monitoring for adverse events in overall patient management.<sup>2</sup>

Several factors may predispose individuals to adverse effects of ARV medications. For example, compared with men, women (especially ART-naïve women with CD4 T lymphocyte cell counts >250 cells/mm<sup>3</sup>) seem to have a higher propensity to develop Stevens-Johnson syndrome, rashes, and hepatotoxicity from nevirapine (NVP)<sup>3-5</sup> and have higher rates of lactic acidosis due to nucleoside reverse transcriptase inhibitors.<sup>6-8</sup> Other factors may also contribute to the development of adverse events:

- Concomitant use of medications with overlapping and additive toxicities;
- Comorbid conditions that increase the risk of or exacerbate adverse effects (e.g., alcoholism<sup>9</sup> or coinfection with viral hepatitis<sup>10-12</sup> increases the risk of hepatotoxicity);
- Drug-drug interactions that may lead to an increase in drug toxicities (e.g., interactions that result from concomitant use of statins with protease inhibitors); or
- Genetic factors that predispose patients to abacavir (ABC) hypersensitivity reaction.<sup>13,14</sup>

The therapeutic goals of ART are to safely achieve and maintain viral suppression and improve immune function. To accomplish these goals, the clinician must consider the toxicity potential of an ARV regimen, as well as the individual patient's underlying conditions, concomitant medications, and prior history of drug intolerances. In addition, it should be appreciated that, in general, the overall benefits of ART outweigh its risks and that some non-AIDS related conditions (e.g., anemia, cardiovascular disease, renal impairment) may be more likely in the absence of ART.<sup>15,16</sup>

Information on the adverse events of ARVs is outlined in several tables in the guidelines. [Table 14](#) provides clinicians with a list of the most common and/or severe known ARV-associated adverse events for each drug class. The most common adverse effects of individual ARV agents are summarized in [Appendix B, Tables 1–6](#).



**Table 14. Antiretroviral Therapy-Associated Common and/or Severe Adverse Effects (page 1 of 5)**

N/A indicates either that there are no reported cases for the particular side effect or that data for the specific ARV drug class are not available. See [Appendix B](#) for additional information listed by drug.

Adverse Effect	NRTIs	NNRTIs	PIs	INSTI	EI
<b>Bleeding Events</b>	N/A	N/A	Spontaneous bleeding, hematuria in hemophilia.  TPV: Intracranial hemorrhage associated with CNS lesions, trauma, alcohol abuse, hypertension, coagulopathy, anti-coagulant or anti-platelet agents, vitamin E	N/A	N/A
<b>Bone Density Effects</b>	TDF: Associated with greater loss of BMD than other NRTIs.  Osteomalacia has been reported in association with proximal renal tubulopathy.	Decreases in BMD observed after the initiation of any ART regimen.			N/A
<b>Bone Marrow Suppression</b>	ZDV: Anemia, neutropenia	N/A	N/A	N/A	N/A
<b>Cardiovascular Disease</b>	ABC and ddI: Associated with an increased risk of MI in some cohort studies. Absolute risk greatest in patients with traditional CVD risk factors.	N/A	Associated with MI and stroke in some cohorts.  SQV/r, ATV/r, and LPV/r: PR prolongation. Risks include pre-existing heart disease, other medications.  SQV/r: QT prolongation. Obtain ECG before administering SQV.	N/A	N/A
<b>Cholelithiasis</b>	N/A	N/A	ATV: Cholelithiasis and kidney stones may present concurrently.  Median onset is 42 months.	N/A	N/A
<b>Diabetes Mellitus/ Insulin Resistance</b>	ZDV, d4T, and ddI	N/A	Reported for some (IDV, LPV/r), but not all PIs	N/A	N/A

**Table 14. Antiretroviral Therapy-Associated Common and/or Severe Adverse Effects (page 2 of 5)**

Adverse Effect	NRTIs	NNRTIs	PIs	INSTI	EI
<b>Dyslipidemia</b>	d4T > ZDV > ABC: ↑LDL and TG	EFV: ↑TG, ↑LDL, ↑HDL	All RTV-boosted PIs: ↑LDL, ↑TG, ↑HDL LPV/r = FPV/r and LPV/r > DRV/r and ATV/r: ↑TG	EVG/c/TDF/FTC: ↑TG, ↑LDL, ↑HDL	N/A
<b>Gastrointestinal Effects</b>	Nausea and vomiting: ddl and ZDV > other NRTIs  Pancreatitis: ddl	N/A	GI intolerance (e.g., diarrhea, nausea, vomiting)  Diarrhea: Common with LPV/r, more frequent than DRV/r and ATV/r	Nausea and diarrhea: EVG/c/TDF/FTC	N/A
<b>Hepatic Effects</b>	Reported with most NRTIs.  Steatosis most common with ZDV, d4T, or ddl.  ddl: Prolonged exposure linked to non-cirrhotic portal hypertension, esophageal varices.  Flares: HIV/HBV-co-infected patients may develop severe hepatic flares when TDF, 3TC, and FTC are withdrawn or when HBV resistance develops.	NVP > other NNRTIs  NVP: Severe hepatotoxicity associated with skin rash or hypersensitivity. 2-week NVP dose escalation may reduce risk. Risk is greater for women with pre-NVP CD4 count >250 cells/mm <sup>3</sup> and men with pre-NVP CD4 count >400 cells/mm <sup>3</sup> . NVP should <b>never</b> be used for post-exposure prophylaxis, or in patients with hepatic insufficiency (Child-Pugh B or C).	All PIs: Drug-induced hepatitis and hepatic decompensation have been reported; greatest frequency with TPV/r.  IDV, ATV: Jaundice due to indirect hyperbilirubinemia  TPV/r: <b>Contraindicated</b> in patients with hepatic insufficiency (Child-Pugh B or C)	N/A	MVC: Hepatotoxicity with or without rash or HSRs reported

**Table 14. Antiretroviral Therapy-Associated Common and/or Severe Adverse Effects (page 3 of 5)**

Adverse Effect	NRTIs	NNRTIs	PIs	INSTI	EI
<b>Hypersensitivity Reaction</b>  Excluding rash alone or Stevens-Johnson syndrome	<p>ABC: <b>Contraindicated</b> if HLA-B*5701 positive. Median onset 9 days; 90% of reactions occur within first 6 weeks of treatment.</p> <p>HSR symptoms (in order of descending frequency): fever, rash, malaise, nausea, headache, myalgia, chills, diarrhea, vomiting, abdominal pain, dyspnea, arthralgia, and respiratory symptoms.</p> <p>Symptoms worsen with continuation of ABC.</p> <p>Patients, regardless of HLA-B*5701 status, should not be re-challenged with ABC if HSR is suspected.</p>	<p>NVP: Hypersensitivity syndrome of hepatotoxicity and rash that may be accompanied by fever, general malaise, fatigue, myalgias, arthralgias, blisters, oral lesions, conjunctivitis, facial edema, eosinophilia, renal dysfunction, granulocytopenia, or lymphadenopathy.</p> <p>Risk is greater for ARV-naïve women with pre-NVP CD4 count &gt;250 cells/mm<sup>3</sup> and men with pre-NVP CD4 count &gt;400 cells/mm<sup>3</sup>. Overall, risk is higher for women than men.</p> <p>2-week dose escalation of NVP reduces risk.</p>	N/A	<p>RAL: HSR reported when RAL given in combination with other drugs known to cause HSR. All ARVs should be stopped if HSR occurs.</p> <p>DTG: Reported in &lt;1% of patients in clinical development program</p>	MVC: Reported as part of a syndrome related to hepatotoxicity
<b>Lactic Acidosis</b>	<p>Reported with NRTIs, especially d4T, ZDV, and ddI: Insidious onset with GI prodrome, weight loss, and fatigue. May rapidly progress with tachycardia, tachypnea, jaundice, weakness, mental status changes, pancreatitis, and organ failure. Mortality high if serum lactate &gt;10 mmol/L.</p> <p>Women and obese patients at increased risk.</p>	N/A	N/A	N/A	N/A

**Table 14. Antiretroviral Therapy-Associated Common and/or Severe Adverse Effects (page 4 of 5)**

Adverse Effect	NRTIs	NNRTIs	PIs	INSTI	EI
<b>Lipodystrophy</b>	Lipoatrophy: d4T > ZDV. May be more likely when NRTIs combined with EFV than with an RTV-boosted PI.	Lipohypertrophy: Trunk fat increase observed with EFV-, PI-, and RAL-containing regimens; however, causal relationship has not been established.			N/A
<b>Myopathy/ Elevated Creatine Phosphokinase</b>	ZDV: Myopathy	N/A	N/A	RAL: ↑CPK, weakness and rhabdomyolysis	N/A
<b>Nervous System/ Psychiatric Effects</b>	Peripheral neuropathy: d4T > ddI and ddC (can be irreversible).  d4T: Associated with rapidly progressive, ascending neuromuscular weakness resembling Guillain-Barré syndrome (rare)	EFV: Somnolence, insomnia, abnormal dreams, dizziness, impaired concentration, depression, psychosis, and suicidal ideation. Symptoms usually subside or diminish after 2–4 weeks. Bedtime dosing may reduce symptoms. Risks include psychiatric illness, concomitant use of agents with neuropsychiatric effects, and increased EFV concentrations because of genetic factors or increased absorption with food. An association between EFV and suicidal ideation, suicide, and attempted suicide (especially among younger patients and those with history of mental illness or substance abuse) was found in a retrospective analysis of comparative trials.	N/A	All INSTIs: Insomnia  RAL: Depression and suicidal ideation (uncommon)	N/A
<b>Rash</b>	FTC: Hyperpigmentation	All NNRTIs	ATV, DRV, FPV, LPV/r, TPV	RAL, EVG/c/TDF/FTC	MVC

**Table 14. Antiretroviral Therapy-Associated Common and/or Severe Adverse Effects (page 5 of 5)**

Adverse Effect	NRTIs	NNRTIs	PIs	INSTI	EI
<b>Renal Effects/ Urolithiasis</b>	TDF: ↑SCr, proteinuria, hypophosphatemia, urinary phosphate wasting, glycosuria, hypokalemia, non-anion gap metabolic acidosis  Concurrent use with PI appears to increase risk.	N/A	ATV and LPV/r: Increased chronic kidney disease risk in a large cohort study.  IDV: ↑SCr, pyuria, renal atrophy or hydronephrosis  IDV, ATV: Stone, crystal formation; adequate hydration may reduce risk.	COBI (in EVG/c/ TDF/FTC) and DTG: Inhibits Cr secretion without reducing renal glomerular function.	N/A
<b>Stevens-Johnson Syndrome/Toxic Epidermal Necrosis</b>	ddl, ZDV: Reported cases	NVP > DLV, EFV, ETR, RPV	FPV, DRV, IDV, LPV/r, ATV: Reported cases	RAL	N/A

**Key to Abbreviations:** 3TC = lamivudine; ABC = abacavir; ALT = alanine aminotransferase; ARV = antiretroviral; ATV = atazanavir; ATV/r = atazanavir/ritonavir; BMD = bone mineral density; Cr = creatinine; CrCl = creatinine clearance; CNS = central nervous system; COBI or c = cobicistat; CPK = creatine phosphokinase; CVD = cardiovascular disease; d4T = stavudine; ddC = zalcitabine; ddl = didanosine; DLV = delavirdine; DRV = darunavir; DRV/r = darunavir/ritonavir; DTG = dolutegravir; ECG = electrocardiogram; EFV = efavirenz; EI = entry inhibitor; ETR = etravirine; EVG = elvitegravir; FPV = fosamprenavir; FPV/r = fosamprenavir/ritonavir; FTC = emtricitabine; GI = gastrointestinal; HBV = hepatitis B virus; HDL = high-density lipoprotein; HSR = hypersensitivity reaction; IDV = indinavir; INSTI = integrase strand transfer inhibitor; LDL = low-density lipoprotein; LPV/r = lopinavir/ritonavir; MI = myocardial infarction; MVC = maraviroc; NFV = nelfinavir; NNRTI = non-nucleoside reverse transcriptase inhibitor; NRTI = nucleoside reverse transcriptase inhibitor; NVP = nevirapine; PI = protease inhibitor; PT = prothrombin time; RAL = raltegravir; RPV = rilpivirine; RTV = ritonavir; SCr = serum creatinine; SQV = saquinavir; SQV/r = saquinavir/ritonavir; TDF = tenofovir disoproxil fumarate; TG = triglyceride; TPV = tipranavir; TPV/r = tipranavir/ritonavir; ZDV = zidovudine



## Switching Antiretroviral Therapy Because of Adverse Effects

Most patients do not experience treatment-limiting ART-associated toxicities; however, some patients do, and in these cases, ART must be modified. ART-associated adverse events can range from acute and potentially life threatening to chronic and insidious. Acute life-threatening events (e.g., acute hypersensitivity reaction due to ABC, lactic acidosis due to stavudine [d4T] and didanosine [ddI], liver and/or severe cutaneous toxicities due to NVP) usually require the immediate discontinuation of all ARV drugs and re-initiation of an alternative regimen without overlapping toxicity. Non-life threatening toxicities (e.g., urolithiasis with atazanavir [ATV], renal tubulopathy with tenofovir [TDF]) can usually be managed by substituting another ARV agent for the presumed causative agent without interruption of ART. Other, chronic, non-life threatening adverse events (e.g., dyslipidemia) can be addressed either by switching the potentially causative agent for another agent or by managing the adverse event with additional pharmacological or non-pharmacological interventions. Management strategies must be individualized for each patient.

Switching from an effective ARV regimen to a new regimen must be done carefully and only when the potential benefits of the change outweigh the potential complications of altering treatment. The fundamental principle of regimen switching is to maintain viral suppression. When selecting a new agent or regimen, providers should be aware that resistance mutations selected for, regardless of whether previously or currently identified by genotypic resistance testing, are archived in HIV reservoirs, and even if absent from subsequent resistance test results, may reappear under selective pressure. It is critical that providers review the following before implementing any treatment switch:

- the patient's medical and complete ARV history including prior virologic responses to ART;
- resistance test results;
- viral tropism (when maraviroc [MVC] is being considered);
- HLA B\*5701 status (when ABC is being considered);
- co-morbidities;
- adherence history;
- prior intolerances to any medications; and
- concomitant medications and supplements and their potential for drug interactions with ARVs.

Patient acceptance of new food or dosing requirements must also be assessed. In some cases, medication costs may also be a factor to consider before switching treatment. Signs and symptoms of ART-associated adverse events may mimic those of comorbidities, adverse effects of concomitant medications, or HIV infection itself. Therefore, concurrent with ascribing a particular clinical event to ART, alternative causes for the event should be investigated. In the case of a severe adverse event, it may be necessary to discontinue or switch ARVs pending the outcome of such an investigation. For the first few months after an ART switch, the patient should be closely monitored for any new adverse events. The patient's viral load should also be monitored to assure continued viral suppression.

[Table 15](#) lists several major ART-associated adverse events and potential options to appropriately switch agents in an ARV regimen. The table focuses on the ARVs most commonly used in the United States and lists substitutions that are supported by ARV switch studies, findings of comparative ARV trials and observational cohort studies, or expert opinion. Switching a successful ARV regimen should be done carefully and only when the potential benefits of the change outweigh the potential complications of altering treatment.

**Table 15. Antiretroviral Therapy-Associated Adverse Events That Can Be Managed with Substitution of Alternative Antiretroviral Agent (page 1 of 2)**

Adverse Event	ARV Agent(s)/Drug Class		Comments
	Switch from	Switch to	
<b>Bone Density Effects</b>	TDF <sup>a</sup>	ABC <sup>b</sup>	Declines in BMD have been observed with the start of most ART regimens. Switching from TDF to alternative ARV agents has been shown to increase bone density, but the clinical significance of this increase remains uncertain.
<b>Bone Marrow Suppression</b>	ZDV	TDF or ABC <sup>b</sup>	ZDV has been associated with neutropenia and macrocytic anemia
<b>Central Nervous System/ Neuropsychiatric Side Effects</b>  Dizziness, suicidal ideation, abnormal dreams, depression	EFV	Alternative NNRTI (RPV, ETR, NVP), a PI/c or PI/r, or an INSTI	In most patients, EFV-related CNS effects subside within 4 weeks after initiation of the drug. Persistent or intolerable effects should prompt substitution of EFV.
<b>Dyslipidemia</b>  Hypertriglyceridemia (with or without elevated low-density LDL level)	RTV- or COBI-boosted regimens or EFV	RAL, DTG, RPV, NVP, or unboosted ATV <sup>c</sup>	Elevated TG and LDL levels are more common with LPV/r and FPV/r than with other RTV-boosted PIs. Improvements in TG and LDL levels observed with switch from LPV/r to ATV or ATV/r. <sup>c</sup>
<b>Gastrointestinal Effects</b>  Nausea, diarrhea	LPV/r	ATV/c, ATV/r, DRV/c, DRV/r, RAL, DTG, EVG/c/TDF/FTC	GI intolerance is common with boosted PIs and is linked to the total dose of RTV. More GI toxicity is seen with LPV/r than with ATV/r or DRV/r. GI effects are often transient, and do not warrant substitution unless persistent and intolerable.
	Other RTV- or COBI-boosted regimens	RAL, DTG, unboosted ATV, <sup>c</sup> NNRTIs	In a trial of treatment-naïve patients, rates of diarrhea and nausea were similar for EVG/c/TDF/FTC and ATV/r plus TDF/FTC.
<b>Hypersensitivity Reaction</b>	ABC	TDF	Never re-challenge with ABC following a suspected HSR, regardless of the patient's HLA B*5701 status.
	NVP, EFV, ETR, RPV	Non-NNRTI ART	Risk of HSR with NVP is higher for women and those with high CD4 cell counts.
	DTG, RAL MVC	Non-INSTI ART Suitable alternative ART	Reactions to NVP, ETR, RAL, DTG and MVC may be accompanied by elevated liver transaminases.
<b>Insulin Resistance</b>	LPV/r, FPV/r	NNRTI (NVP or RPV), INSTI, unboosted ATV <sup>c</sup>	Results of switch studies have been inconsistent. Studies in HIV-negative patients suggest a direct causal effect of LPV/r (and IDV) on insulin resistance. However, traditional risk factors may be stronger risk factors for insulin resistance than use of any PI.
<b>Jaundice and Icterus</b>	ATV, ATV/c, ATV/r	DRV/c, DRV/r, INSTI, or NNRTI	Increases in unconjugated bilirubin are common with ATV and generally do not require modification of therapy unless resultant symptoms are distressing to the patient.

**Table 15. Antiretroviral Therapy-Associated Adverse Events That Can Be Managed with Substitution of Alternative Antiretroviral Agent (page 2 of 2)**

Adverse Event	ARV Agent(s)/Drug Class		Comments
	Switch from	Switch to	
<b>Lipoatrophy</b> Subcutaneous fat wasting of limbs, face, buttocks	d4T, ZDV	TDF or ABC <sup>b</sup>	Peripheral lipoatrophy is a legacy of prior thymidine analog (d4T and ZDV) use. Switching from these ARVs prevents worsening lipoatrophy, but fat recovery is typically slow (may take years) and incomplete.
<b>Lipohypertrophy</b>	Accumulation of visceral, truncal, dorso-cervical, and breast fat has been observed during ART, particularly during use of older PI-based regimens (e.g., IDV), but whether ART directly causes increased fat deposits remains unclear. There is no clinical evidence that switching to another first line regimen will reverse weight or visceral fat gain.		
<b>Rash</b>	NNRTIs (especially NVP and EFV)	PI- or INSTI-based regimen	Mild rashes developing after initiation of NNRTIs other than NVP rarely require treatment switch. When serious rash develops due to any NNRTI, switch to another drug class.
	DRV/c, DRV/r	ATV/c, ATV/r or another drug class (e.g., INSTI)	Mild rashes following DRV/r may resolve with close follow-up only. For more severe reactions, change to an alternative boosted PI or an agent from another drug class.
<b>Renal Effects</b> Including proximal renal tubulopathy, elevated creatinine	TDF <sup>a</sup>	ABC <sup>b</sup>	TDF may cause tubulopathy.
	ATV/c, ATV/r, LPV/r	DTG, RAL, or NNRTI	COBI and DTG, and to a lesser extent RPV can increase SCr through inhibition of creatinine secretion. This effect does not affect glomerular filtration. However, assess for renal dysfunction if SCr increases by >0.4 mg/dL.
<b>Stones</b> Nephrolithiasis and cholelithiasis	ATV, ATV/c, ATV/r	DRV/c, DRV/r, INSTI, or NNRTI	Assuming that ATV/r is believed to cause the stones

<sup>a</sup> In patients with chronic active HBV infection, another agent active against HBV should be substituted for TDF.

<sup>b</sup> ABC should be used only in patients known to be HLA-B\*5701 negative.

<sup>c</sup> TDF reduces ATV levels; therefore, unboosted ATV should not be coadministered with TDF. Long term data for unboosted ATV are unavailable.

**Key to Abbreviations:** ABC = abacavir; ART = antiretroviral therapy; ARV = antiretroviral; ATV = atazanavir; ATV/c = atazanavir/cobicistat; ATV/r = atazanavir/ritonavir; BMD = bone mineral density; CD4 = CD4 T lymphocyte; CNS = central nervous system; COBI or c = cobicistat; d4T = stavudine; DRV/c = darunavir/cobicistat; DRV/r = darunavir/ritonavir; DTG = dolutegravir; EFV = efavirenz; ETR = etravirine; EVG = elvitegravir; FPV/r = fosamprenavir/ritonavir; FTC = emtricitabine; GI = gastrointestinal; HBV = hepatitis B virus; HSR = hypersensitivity reaction; IDV = indinavir; INSTI = integrase strand transfer inhibitor; LDL = low-density lipoprotein; LPV/r = lopinavir/ritonavir; MVC = maraviroc; NNRTI = non-nucleoside reverse transcriptase inhibitor; NVP = nevirapine; PI = protease inhibitor; PI/c = protease inhibitor/cobicistat; PI/r = protease inhibitor/ritonavir; RAL = raltegravir; RPV = rilpivirine; RTV = ritonavir; SCr = serum creatinine; TDF = tenofovir disoproxil fumarate; TG = triglycerides; ZDV = zidovudine

## References

- O'Brien ME, Clark RA, Besch CL, et al. Patterns and correlates of discontinuation of the initial HAART regimen in an urban outpatient cohort. *J Acquir Immune Defic Syndr*. 2003;34(4):407-414. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list\\_uids=14615659](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=14615659).
- Keiser O, Fellay J, Opravil M, et al. Adverse events to antiretrovirals in the Swiss HIV Cohort Study: effect on mortality and treatment modification. *Antivir Ther*. 2007;12(8):1157-1164. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list\\_uids=18240856](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=18240856).

3. Baylor MS, Johann-Liang R. Hepatotoxicity associated with nevirapine use. *J Acquir Immune Defic Syndr*. 2004;35(5):538-539. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list\\_uids=15021321](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=15021321).
4. Bersoff-Matcha SJ, Miller WC, Aberg JA, et al. Sex differences in nevirapine rash. *Clin Infect Dis*. 2001;32(1):124-129. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list\\_uids=11118391&dopt=Abstract](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uids=11118391&dopt=Abstract).
5. Fagot JP, Mockenhaupt M, Bouwes-Bavinck JN, for the EuroSCAR study group. Nevirapine and the risk of Stevens-Johnson syndrome or toxic epidermal necrolysis. *AIDS*. 2001;15(14):1843-1848. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list\\_uids=11579247&dopt=Abstract](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uids=11579247&dopt=Abstract).
6. Moyle GJ, Datta D, Mandalia S, et al. Hyperlactataemia and lactic acidosis during antiretroviral therapy: relevance, reproducibility and possible risk factors. *AIDS*. 2002;16(10):1341-1349. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list\\_uids=12131210&dopt=Abstract](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uids=12131210&dopt=Abstract).
7. Bolhaar MG, Karstaedt AS. A high incidence of lactic acidosis and symptomatic hyperlactatemia in women receiving highly active antiretroviral therapy in Soweto, South Africa. *Clin Infect Dis*. 2007;45(2):254-260. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list\\_uids=17578788](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=17578788).
8. Geddes R, Knight S, Moosa MY, Reddi A, Uebel K, H S. A high incidence of nucleoside reverse transcriptase inhibitor (NRTI)-induced lactic acidosis in HIV-infected patients in a South African context. *S Afr Med J*. 2006;96(8):722-724. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list\\_uids=17019496](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=17019496).
9. Dieterich DT, Robinson PA, Love J, Stern JO. Drug-induced liver injury associated with the use of nonnucleoside reverse-transcriptase inhibitors. *Clin Infect Dis*. 2004;38(Suppl 2):S80-89. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list\\_uids=14986279](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=14986279).
10. den Brinker M, Wit FW, Wertheim-van Dillen PM, et al. Hepatitis B and C virus co-infection and the risk for hepatotoxicity of highly active antiretroviral therapy in HIV-1 infection. *AIDS*. 2000;14(18):2895-2902. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=11153671](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11153671).
11. Saves M, Raffi F, Clevenbergh P, et al. Hepatitis B or hepatitis C virus infection is a risk factor for severe hepatic cytolysis after initiation of a protease inhibitor-containing antiretroviral regimen in human immunodeficiency virus-infected patients. The APROCO Study Group. *Antimicrob Agents Chemother*. 2000;44(12):3451-3455. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=11083658](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11083658).
12. Sulkowski MS, Thomas DL, Chaisson RE, Moore RD. Hepatotoxicity associated with antiretroviral therapy in adults infected with human immunodeficiency virus and the role of hepatitis C or B virus infection. *JAMA*. 2000;283(1):74-80. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=10632283](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=10632283).
13. Mallal S, Phillips E, Carosi G, et al. HLA-B\*5701 screening for hypersensitivity to abacavir. *N Engl J Med*. 2008;358(6):568-579. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list\\_uids=18256392](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=18256392).
14. Saag M, Balu R, Phillips E, et al. High sensitivity of human leukocyte antigen-b\*5701 as a marker for immunologically confirmed abacavir hypersensitivity in white and black patients. *Clin Infect Dis*. 2008;46(7):1111-1118. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list\\_uids=18444831](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=18444831).
15. El-Sadr WM, Lundgren JD, Neaton JD, et al. CD4+ count-guided interruption of antiretroviral treatment. *N Engl J Med*. 2006;355(22):2283-2296. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17135583](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17135583).
16. Lichtenstein KA, Armon C, Buchacz K, et al. Initiation of antiretroviral therapy at CD4 cell counts  $\geq 350$  cells/mm<sup>3</sup> does not increase incidence or risk of peripheral neuropathy, anemia, or renal insufficiency. *J Acquir Immune Defic Syndr*. 2008;47(1):27-35. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=17971714](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17971714).

## Cost Considerations and Antiretroviral Therapy (Last updated May 1, 2014; last reviewed May 1, 2014)

Although antiretroviral therapy (ART) is expensive (see [Table 16](#) below), the cost-effectiveness of ART has been demonstrated in analyses of older<sup>1</sup> and newer regimens,<sup>2,3</sup> as well as for treatment-experienced patients with drug-resistant HIV.<sup>4</sup> Given the recommendations for immediate initiation of lifelong treatment and the increasing number of patients taking ART, the Panel now introduces cost-related issues pertaining to medication adherence and cost-containment strategies, as discussed below.

### *Costs as They Relate to Adherence from a Patient Perspective*

**Cost sharing:** Cost sharing is where the patient is responsible for some of the medication cost burden (usually accomplished via co-payments, co-insurance, or deductibles); these costs are often higher for branded medications than for generic medications. In one comprehensive review, increased patient cost sharing resulted in decreased medical adherence and more frequent drug discontinuation; for patients with chronic diseases, increased cost sharing was also associated with increased use of the medical system.<sup>5</sup> Conversely, co-payment reductions, such as those that might be used to incentivize prescribing of generic drugs, have been associated with improved adherence in patients with chronic diseases.<sup>6</sup> Whereas cost-sharing disproportionately affects low income patients, resources (e.g., the Ryan White AIDS Drug Assistance Program [ADAP]) are available to assist eligible patients with co-pays and deductibles. Given the clear association between out-of-pocket costs for patients with chronic diseases and the ability of those patients to pay for and adhere to medications, clinicians should minimize patients' out-of-pocket drug-related expenses whenever possible.

**Prior authorizations:** As a cost-containment strategy, some programs require that clinicians obtain prior authorizations or permission before prescribing newer or more costly treatments rather than older or less expensive drugs. Although there are data demonstrating that prior authorizations do reduce spending, several studies have also shown that prior authorizations result in fewer prescriptions filled and increased non-adherence.<sup>7-9</sup> Prior authorizations in HIV care specifically have been reported to cost over \$40 each in provider personnel time (a hidden cost) and have substantially reduced timely access to medications.<sup>10</sup>

**Generic ART:** The impact of the availability of generic antiretroviral (ARV) drugs on selection of ART in the United States is unknown. Because U.S. patent laws currently limit the co-formulation of some generic alternatives to branded drugs, generic options may result in increased pill burden. To the extent that pill burden, rather than drug frequency, results in reduced adherence, generic ART could lead to decreased costs but at the potential expense of worsening virologic suppression rates and poorer clinical outcomes.<sup>11,12</sup> Furthermore, prescribing the individual, less-expensive generic components of a branded co-formulated product rather than the branded product itself could, under some insurance plans, lead to higher copays—an out-of-pocket cost increase that may reduce medication adherence.

### *Potential Cost Containment Strategies from a Societal Perspective*

Given resource constraints, it is important to maximize the use of resources without sacrificing clinical outcomes. Evidence-based revisions to these guidelines recommend tailored laboratory monitoring for patients with long-term virologic suppression on ART as one possible way to provide overall cost savings. Data suggest that continued CD4 monitoring yields no clinical benefit for patients whose viral loads are suppressed and CD4 counts exceed 200 cells/mm<sup>3</sup> after 48 weeks of therapy.<sup>13</sup> A reduction in laboratory use from biannual to annual CD4 monitoring could save ~\$10 million per year in the United States<sup>14</sup> (see the [Laboratory Monitoring](#) section). Although this is a small proportion of the overall costs associated with HIV care, such a strategy could reduce patients' personal expenses if they have deductibles for laboratory tests. The present and future availability of generic formulations of certain ARV drugs, despite the potential caveats of increased pill burden and reduced adherence, offers other money-saving possibilities on a much



greater scale. One analysis suggests the possibility of saving approximately \$900 million nationally in the first year of switching from a branded fixed-dose combination product to a three-pill regimen containing generic efavirenz.<sup>3</sup>

In summary, understanding HIV and ART-related costs in the United States is complicated because of the wide variability in medical coverage, accessibility, and expenses across regions, insurance plans, and pharmacies. In an effort to retain excellent clinical outcomes in an environment of cost-containment strategies, providers should remain informed of current insurance and payment structures, ART costs (see Table 16 below for estimates of drugs' average wholesale prices), discounts among preferred pharmacies, and available generic ART options. Providers should work with patients and their case managers and social workers to understand their patients' particular pharmacy benefit plans and potential financial barriers to filling their prescriptions. Additionally, providers should familiarize themselves with ARV affordability resources (such as ADAP and pharmaceutical company patient assistance programs for patients who qualify) and refer patients to such assistance if needed.

**Table 16. Monthly Average Wholesale Price<sup>a</sup> of Antiretroviral Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 1 of 4)**

ARV Drug (Generic and Brand Names)	Strength	Dosing	Tablets/Capsules/ mLs per Month	AWP <sup>a</sup> (Monthly)
<b>Nucleoside Reverse Transcriptase Inhibitors (NRTIs)</b>				
<b>Abacavir</b>				
• Generic	300 mg tab	2 tabs daily	60 tabs	\$602.66
• Ziagen	300 mg tab	2 tabs daily	60 tabs	\$670.37
• Ziagen	20 mg/mL soln	30 mL daily	900 mL	\$660.86
<b>Didanosine Delayed-Release</b>				
• Generic	400 mg cap	1 cap daily	30 caps	\$368.72
• Videx EC	400 mg cap	1 cap daily	30 caps	\$515.84
<b>Emtricitabine</b>				
• Emtriva	200 mg cap	1 cap daily	30 caps	\$602.27
• Emtriva	10 mg/mL soln	24 mL daily	680 mL (28-day supply)	\$568.88
<b>Lamivudine</b>				
• Generic	300 mg tab	1 tab daily	30 tabs	\$429.66
• Epivir	300 mg tab	1 tab daily	30 tabs	\$498.89
• Epivir	10 mg/mL soln	30 mL daily	900 mL	\$498.90
<b>Stavudine</b>				
• Generic	40 mg cap	1 cap twice daily	60 caps	\$410.70
• Zerit	40 mg cap	1 cap twice daily	60 caps	\$553.12
<b>Tenofovir</b>				
• Viread	300 mg tab	1 tab daily	30 tabs	\$1,120.04
<b>Zidovudine</b>				
• Generic	300 mg tab	1 tab twice daily	60 tabs	\$360.97

**Table 16. Monthly Average Wholesale Price<sup>a</sup> of Antiretroviral Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 2 of 4)**

ARV Drug (Generic and Brand Names)	Strength	Dosing	Tablets/Capsules/ mLs per Month	AWP <sup>a</sup> (Monthly)
<b>NRTI Combination Products</b>				
<b>Abacavir/Lamivudine</b> • Epzicom	600/300 mg tab	1 tab daily	30 tabs	\$1,416.35
<b>Tenofovir Disoproxil Fumarate/ Emtricitabine</b> • Truvada	300/200 mg tab	1 tab daily	30 tabs	\$1,539.90
<b>Zidovudine/Lamivudine</b> • Generic	300/150 mg tab	1 tab twice daily	60 tabs	\$931.61
• Combivir	300/150 mg tab	1 tab twice daily	60 tabs	\$1,081.70
<b>Abacavir Sulfate/Zidovudine/ Lamivudine</b> • Generic	300/300/150 mg tab	1 tab twice daily	60 tabs	\$1,738.46
• Trizivir	300/300/150 mg tab	1 tab twice daily	60 tabs	\$1,931.64
<b>Non-Nucleoside Reverse Transcriptase Inhibitors (NNRTIs)</b>				
<b>Efavirenz</b> • Sustiva	600 mg tab	1 tab daily	30 tabs	\$1,011.97
<b>Etravirine</b> • Intelence	200 mg tab	1 tab twice daily	60 tabs	\$1,212.29
<b>Nevirapine</b> • Generic	200 mg tab	1 tab twice daily	60 tabs	\$650.05
• Viramune	200 mg tab	1 tab twice daily	60 tabs	\$861.19
• Viramune XR (nevirapine extended release)	400 mg tab	1 tab daily	30 tabs	\$798.73
<b>Rilpivirine</b> • Edurant	25 mg tab	1 tab daily	30 tabs	\$996.43
<b>Protease Inhibitors (PIs)</b>				
<b>Atazanavir</b> • Reyataz	200 mg cap	2 caps daily	60 caps	\$1,535.23
• Reyataz	300 mg cap <sup>c</sup>	1 cap daily	30 caps	\$1,520.72
<b>Atazanavir/Cobicistat</b> • Evotaz	300 mg/150 mg tab	1 tab daily	30 tabs	\$1,684.44
<b>Darunavir</b> • Prezista	600 mg tab <sup>b</sup>	1 tab twice daily	60 tabs	\$1,509.79
• Prezista	800 mg tab <sup>c</sup>	1 tab daily	30 tabs	\$1,509.79
• Prezista	100 mg/mL susp <sup>b</sup>	8 mL daily 6 mL twice daily	240 mL 360 mL	\$1,006.54 \$1,509.80
<b>Darunavir/Cobicistat</b> • Prezcobix	800 mg/150 mg tab	1 tab daily	30 tabs	\$1,725.29

**Table 16. Monthly Average Wholesale Price<sup>a</sup> of Antiretroviral Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 3 of 4)**

ARV Drug (Generic and Brand Names)	Strength	Dosing	Tablets/Capsules/ mLs per Month	AWP <sup>a</sup> (Monthly)
<b>Protease Inhibitors (PIs), continued</b>				
<b>Fosamprenavir</b> • Lexiva	700 mg tab	2 tabs twice daily	120 tabs	\$2,408.86
• Lexiva	700 mg tab	1 tab twice daily <sup>b</sup> or 2 tabs once daily <sup>b</sup>	60 tabs	\$1,204.43
<b>Lopinavir/Ritonavir</b> • Kaletra	200 mg/50 mg tab	2 tabs twice daily or 4 tabs once daily	120 tabs	\$977.22
• Kaletra	80 mg/20 mg per mL soln	5 mL twice daily	300 mL	\$916.13
<b>Nelfinavir</b> • Viracept	625 mg tab	2 tabs twice daily	120 tabs	\$1,169.22
<b>Saquinavir</b> • Invirase	500 mg tab <sup>b</sup>	2 tabs twice daily	120 tabs	\$1,260.01
<b>Tipranavir</b> • Aptivus	250 mg cap <sup>b</sup>	2 caps twice daily	120 caps	\$1,590.18
<b>Integrase Strand Transfer Inhibitors (INSTIs)</b>				
<b>Dolutegravir</b> • Tivicay	50 mg tab	1 tab once daily	30 tabs	\$1,581.68
• Tivicay	50 mg tab	1 tab twice daily	60 tabs	\$3,163.36
<b>Elvitegravir</b> • Vitekta	85 mg tab	1 tab daily	30 tabs	\$1,352.05
• Vitekta	150 mg tab	1 tab daily	30 tabs	\$1,352.05
<b>Raltegravir</b> • Isentress	400 mg tab	1 tab twice daily	60 tabs	\$1,445.34
<b>Fusion Inhibitor</b>				
<b>Enfuvirtide</b> • Fuzeon	90 mg injection kit	1 injection twice daily	60 doses (1 kit)	\$3,759.43
<b>CCR5 Antagonist</b>				
<b>Maraviroc</b> • Selzentry	150 mg tab	1 tab twice daily	60 tabs	\$1,455.13
• Selzentry	300 mg tab	1 tab twice daily	60 tabs	\$1,455.13
• Selzentry	300 mg tab	2 tabs twice daily	120 tabs	\$2,910.26
<b>Co-Formulated Combination Products as Single Tablet Regimens</b>				
<b>Dolutegravir/Abacavir/Lamivudine</b> • Trumeq	50/600/300 mg tab	1 tab daily	30 tabs	\$2,648.84
<b>Efavirenz/Tenofovir Disoproxil Fumarate/Emtricitabine</b> • Atripla	600/300/200 mg tab	1 tab daily	30 tabs	\$2,551.99
<b>Elvitegravir/Cobicistat/Tenofovir Disoproxil Fumarate/ Emtricitabine</b> • Stribild	150/150/300/200 mg tab	1 tab daily	30 tabs	\$2,948.70

**Table 16. Monthly Average Wholesale Price<sup>a</sup> of Antiretroviral Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 4 of 4)**

ARV Drug (Generic and Brand Names)	Strength	Dosing	Tablets/Capsules/ mLs per Month	AWP <sup>a</sup> (Monthly)
<b>Co-Formulated Combination Products as Single Tablet Regimens, continued</b>				
<b>Rilpivirine/Tenofovir Disoproxil Fumarate/Emtricitabine</b> • Complera	25/300/200 mg tab	1 tab daily	30 tabs	\$2,463.37
<b>Pharmacokinetic Enhancers (Boosters)</b>				
<b>Cobicistat</b> • Tybost	150 mg tab	1 tab daily	30 tabs	\$216.00
<b>Ritonavir</b> - Total Daily Dose Depends On Concomitant PI (100 mg once or twice daily, or 200 mg twice daily) • Generic	100 mg tab	1 tab once daily	30 tabs	Price not yet available
• Norvir	100 mg tab	1 tab once daily	30 tabs	\$308.60
	80 mg/mL soln	100 mg daily	37.5 mL (of a 240 mL bottle)	\$270.04

<sup>a</sup> AWP = Average Wholesale Price. Note that this price may not represent the pharmacy acquisition price or the price paid by consumers. Source: <http://micromedex.com/redbook>. Accessed February 2015.

<sup>b</sup> Should be used in combination with ritonavir. Please refer to [Appendix B, Table 3](#) for ritonavir doses.

<sup>c</sup> Should be used in combination with ritonavir or cobicistat. Please refer to [Appendix B, Table 3](#) for ritonavir doses.

**Key to Abbreviations:** AWP = average wholesale price; cap = capsule; EC = enteric coated; soln = solution; susp = suspension; tab = tablet; XR = extended release

## References

1. Freedberg KA, Losina E, Weinstein MC, et al. The cost effectiveness of combination antiretroviral therapy for HIV disease. *N Engl J Med*. 2001;344(11):824-831. Available at [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list\\_uids=11248160](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=11248160).
2. Mauskopf J, Brogan AJ, Talbird SE, Martin S. Cost-effectiveness of combination therapy with etravirine in treatment-experienced adults with HIV-1 infection. *AIDS*. 2012;26(3):355-364. Available at <http://www.ncbi.nlm.nih.gov/pubmed/22089378>.
3. Walensky RP, Sax PE, Nakamura YM, et al. Economic savings versus health losses: the cost-effectiveness of generic antiretroviral therapy in the United States. *Ann Intern Med*. 2013;158(2):84-92. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23318310>.
4. Bayoumi AM, Barnett PG, Joyce VR, et al. Cost-effectiveness of newer antiretroviral drugs in treatment-experienced patients with multidrug-resistant HIV disease. *J Acquir Immune Defic Syndr*. 2013;64(4):382-391. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24129369>.
5. Goldman DP, Joyce GF, Zheng Y. Prescription drug cost sharing: associations with medication and medical utilization and spending and health. *JAMA*. 2007;298(1):61-69. Available at <http://www.ncbi.nlm.nih.gov/pubmed/17609491>.
6. Maciejewski ML, Farley JF, Parker J, Wansink D. Copayment reductions generate greater medication adherence in targeted patients. *Health Affair*. 2010;29(11):2002-2008. Available at <http://www.ncbi.nlm.nih.gov/pubmed/21041739>.
7. Abdelgawad T, Egbonu-Davis L. Preferred drug lists and Medicaid prescriptions. *PharmacoEconomics*. 2006;24 Suppl 3:55-63. Available at <http://www.ncbi.nlm.nih.gov/pubmed/17266388>.
8. Ridley DB, Axelsen KJ. Impact of Medicaid preferred drug lists on therapeutic adherence. *PharmacoEconomics*. 2006;24 Suppl 3:65-78. Available at <http://www.ncbi.nlm.nih.gov/pubmed/17266389>.

9. Wilson J, Axelsen K, Tang S. Medicaid prescription drug access restrictions: exploring the effect on patient persistence with hypertension medications. *Am J Manag Care*. 2005;11 Spec No:SP27-34. Available at <http://www.ncbi.nlm.nih.gov/pubmed/15700907>.
10. Raper JL, Willig JH, Lin HY, et al. Uncompensated medical provider costs associated with prior authorization for prescription medications in an HIV clinic. *Clin Infect Dis*. 2010;51(6):718-724. Available at <http://www.ncbi.nlm.nih.gov/pubmed/20695800>.
11. Hanna DB, Hessel NA, Golub ET, et al. Increase in Single-Tablet Regimen Use and Associated Improvements in Adherence-Related Outcomes in HIV-Infected Women. *J Acquir Immune Defic Syndr*. 2013. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24326606>.
12. Nachega JB, Parienti JJ, Uthman OA, et al. Lower Pill Burden and Once-daily Dosing Antiretroviral Treatment Regimens for HIV Infection: A Meta-Analysis of Randomized Controlled Trials. *Clin Infect Dis*. 2014. Available at <http://www.ncbi.nlm.nih.gov/pubmed/24457345>.
13. Girard PM, Nelson M, Mohammed P, Hill A, van Delft Y, Moecklinghoff C. Can we stop CD4 testing in patients with HIV-1 RNA suppression on antiretroviral treatment? Analysis of the ARTEMIS trial. *AIDS*. 2013. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23842127>.
14. Hyle EP, Sax PE, Walensky RP. Potential Savings by Reduced CD4 Monitoring in Stable Patients With HIV Receiving Antiretroviral Therapy. *JAMA Intern Med*. 2013. Available at <http://www.ncbi.nlm.nih.gov/pubmed/23978894>.



## Drug-Drug Interactions (Last updated April 8, 2015; last reviewed April 8, 2015)

Pharmacokinetic (PK) drug-drug interactions between antiretroviral (ARV) drugs and concomitant medications are common, and may lead to increased or decreased drug exposure. In some instances, changes in drug exposure may increase toxicities or affect therapeutic responses. When prescribing or switching one or more drugs in an ARV regimen, clinicians must consider the potential for drug-drug interactions—both those that affect ARVs and those that ARVs affect on other drugs a patient is taking. A thorough review of concomitant medications in consultation with a clinician with expertise in ARV pharmacology can help in designing a regimen that minimizes undesirable interactions. Recommendations for managing a particular drug interaction may differ depending on whether a new ARV is being initiated in a patient on a stable concomitant medication or a new concomitant medication is being initiated in a patient on a stable ARV regimen. The magnitude and significance of interactions are difficult to predict when several drugs with competing metabolic pathways are prescribed concomitantly. When prescribing interacting drugs is necessary, clinicians should be vigilant in monitoring for therapeutic efficacy and/or concentration-related toxicities.

### Mechanisms of Pharmacokinetic Interactions

PK interactions may occur during absorption, metabolism, or elimination of the ARV and/or the interacting drugs. The most common mechanisms of interactions are described below and listed for each ARV drug in [Table 17](#).

#### *Pharmacokinetic Interactions Affecting Drug Absorption*

The extent of oral absorption of drugs can be affected by the following mechanisms:

- Acid reducing agents, such as proton pump inhibitors, H<sub>2</sub> antagonists, or antacids, can reduce the absorption of ARVs that require gastric acidity for optimal absorption (i.e., atazanavir [ATV] and rilpivirine [RPV]).
- Products that contain polyvalent cations, such as aluminum, calcium, magnesium-containing antacids, supplements, or iron products, can bind to integrase inhibitors (INSTI) and reduce absorption of these ARV agents.
- Drugs that induce or inhibit the enzyme CYP3A4 or efflux transporter p-glycoprotein in the intestines may reduce or promote the absorption of other drugs.

#### *Pharmacokinetic Interactions Affecting Hepatic Metabolism*

Two major enzyme systems are most frequently responsible for clinically significant drug interactions.

1. The cytochrome P450 enzyme system is responsible for the metabolism of many drugs, including the non-nucleoside reverse transcriptase inhibitors (NNRTI), protease inhibitors (PI), CCR5 antagonist maraviroc (MVC), and the INSTI elvitegravir (EVG). Cytochrome P450 3A4 (CYP3A4) is the most common enzyme responsible for drug metabolism, though multiple enzymes may be involved in the metabolism of a drug. ARVs and concomitant medications may be inducers, inhibitors, and/or substrates of these enzymes.
2. The uridine diphosphate (UDP)-glucuronosyltransferase (UGT) 1A1 enzyme is the primary enzyme responsible for the metabolism of the INSTIs dolutegravir (DTG) and raltegravir (RAL). Drugs that induce or inhibit the UGT enzyme can affect the PKs of these INSTIs.

#### *Pharmacokinetic Enhancers (Boosters)*

PK enhancing is a strategy used to increase exposure of an ARV by concomitantly administering a drug that inhibits the enzymes that metabolize the ARV. Currently in clinical practice, two agents are used as PK enhancers: ritonavir (RTV) and cobicistat (COBI). Both of these agents are potent inhibitors of the CYP3A4 enzyme, resulting in higher drug exposures of the coadministered ARV metabolized by this pathway.

Importantly, RTV and COBI may have different effects on other CYP or UGT metabolizing enzymes and drug transporters. Complex or unknown mechanisms of PK-based interactions preclude extrapolation of RTV drug interactions to certain COBI interactions, such as interactions with warfarin, phenytoin, voriconazole, oral contraceptives, certain HMG-CoA reductase inhibitors (or statins), and other drugs.

### ***Other Mechanisms of Pharmacokinetic Interactions***

Knowledge of drug transporters is evolving, elucidating additional drug interaction mechanisms. For example, DTG decreases the renal clearance of metformin by inhibiting organic anion transporters in renal tubular cells. Similar transporters aid hepatic, renal, and biliary clearance of drugs and may be susceptible to drug interactions. ARVs and concomitant medications may be inducers, inhibitors, and/or substrates of these drug transporters.

[Tables 18–20b](#) provide information on known or suspected drug interactions between ARV agents and commonly prescribed medications based on published PK data or information from product labels. The tables provide general guidance on drugs that should not be coadministered and recommendations for dose modifications or alternative therapy.

**Table 17. Mechanisms of Antiretroviral-Associated Drug Interactions (page 1 of 2)**

Pharmacokinetic interactions may occur during absorption, metabolism, or elimination of the ARV and/or the interacting drugs. This table does not include a comprehensive list of all possible mechanisms of interactions for individual ARV drugs (e.g., transporters); however, the table lists the most common mechanisms of interactions and focuses on absorption and CYP and UGT1A1 mediated interactions.

**Note:** Ellipses ( ... ) indicate that there are no clinically relevant interactions by these mechanisms.

ARV Drugs by Drug Class	Mechanisms That May Affect or Be Affected by Oral Absorption of ARV Drugs			Enzymes That Metabolize or Are Induced or Inhibited by ARV Drugs				Other Mechanisms of Drug Interactions
	Increasing Gastric pH	Cationic Chelation	P-glycoprotein	CYP Substrate	CYP Inhibitor	CYP Inducer	UGT1A1	
Integrase Strand Transfer Inhibitors (INSTIs)								
Dolutegravir (DTG)	...	Concentration decreased by products containing polyvalent cations (e.g., Ca, Mg, Al, Fe, Zn)	Substrate	3A4 (small contribution)	...	...	Substrate	Inhibitor of renal transporters OCT2 and MATE
Elvitegravir (EVG)	...		...	3A4	...	...	Substrate	...
Raltegravir (RAL)	...		...	...	...	...	Substrate	...
Pharmacokinetic (PK) Enhancers (Boosters)								
Cobicistat (COBI)	...	...	Inhibitor	3A4	3A4, 2D6	...	...	...
Ritonavir (RTV)	...	...	Substrate, inhibitor	3A4, 2D6	3A4, 2D6 (lesser extent)	1A2, 2C8, 2C9, 2C19	Inducer	...
Protease Inhibitors (PIs)								
Note: When PIs are coadministered with PK enhancers (boosters), the pharmacologic properties of both agents should be considered when assessing potential drug interactions.								
Atazanavir (ATV)	Concentration decreased	...	Substrate, inducer, inhibitor	3A4	3A4, 2C8 (weak)	...	Inhibitor	...
Darunavir (DRV)	...	...	Substrate	3A4	3A4	2C9	...	...

**Table 17. Mechanisms of Antiretroviral-Associated Drug Interactions (page 2 of 2)**

ARV Drugs by Drug Class	Mechanisms That May Affect or be Affected by Oral Absorption of ARV Drugs			Enzymes That Metabolize or are Induced or Inhibited by ARV Drugs				Other Mechanisms of Drug Interactions
	Increasing Gastric pH	Cationic Chelation	P-glycoprotein	CYP Substrate	CYP Inhibitor	CYP Inducer	UGT1A1	
Protease Inhibitors (PIs), continued								
Note: When PIs are coadministered with PK enhancers (boosters), the pharmacologic properties of both agents should be considered when assessing potential drug interactions.								
Fosampren-avir (FPV)	Concentration decreased by H2 antagonist	...	Substrate, inhibitor	3A4	3A4	3A4 (weak)	...	...
Lopinavir (LPV)	...	...	Substrate	3A4	3A4	...	...	...
Saquinavir (SQV)	...	...	Substrate, inhibitor	3A4	3A4	...	...	...
Tipranavir (TPV)	...	...	Substrate, inducer	3A4	2D6	3A4, 1A2, 2C19	...	...
Non-nucleoside Reverse Transcriptase Inhibitors (NNRTIs)								
Efavirenz (EFV)	...	...	...	2B6 (primary), 2A6, 3A4	2C9, 2C19, 3A4	3A4, 2B6	...	...
Etravirine (ETR)	...	...	Inducer	3A4, 2C9, 2C19	2C9, 2C19	3A4	...	...
Nevirapine (NVP)	...	...	...	3A4, 2B6	...	3A4, 2B6	...	...
Rilpivirine (RPV)	Concentration decreased	...	...	3A4	...	...	...	...
Nucleoside Reverse Transcriptase Inhibitors (NRTIs)								
Abacavir (ABC)	...	...	...	...	...	...	Substrate	Alcohol dehydrogenase substrate
Emtricitabine (FTC)	...	...	...	...	...	...	...	...
Lamivudine (3TC)	...	...	...	...	...	...	...	...
Tenofovir (TDF)	...	...	Substrate	...	...	...	...	Competition of active renal tubular secretion
Zidovudine (ZDV)	...	...	...	...	...	...	...	Glucuronidation
CCR5 Antagonist								
Maraviroc (MVC)	...	...	Substrate	3A4	...	...	...	...
Fusion Inhibitor								
Enfuvirtide (T20)	...	...	...	...	...	...	...	...

**Key to Abbreviations:** Al = aluminium; ARV = antiretroviral; Ca = calcium; CYP = cytochrome P; Fe = iron; MATE = multidrug and toxin extrusion transporter; Mg = magnesium; OCT2 = organic cation transporter 2; UGT1A1 = uridine diphosphate glucuronosyltransferase; Zn = zinc

**Table 18. Drugs That Should Not Be Used With Antiretroviral Agents (Last updated April 8, 2015; last reviewed April 8, 2015) (page 1 of 2)**

This table only lists drugs that should not be coadministered at any dose, regardless of RTV or COBI enhancing. See Tables 19 and 20 for more detailed PK interaction data.

ARV Agents <sup>a,b</sup>	Cardiac Agents	Lipid-Lowering Agents	Antimycobacterial Agents	Antiepileptic Agents	Neurologic Agents	Herbs	HCV Agents <sup>c</sup>	Other Agents
ATV +/- RTV or COBI	Dronedaron Ranolazine	Lovastatin Simvastatin	Rifampin Rifapentine <sup>d</sup>	None	Lurasidone Midazolam <sup>e</sup> Pimozide Triazolam	St. John's wort	Boceprevir Simeprevir	Alfuzosin Cisapride <sup>f</sup> Ergot derivatives Irinotecan Salmeterol Sildenafil for PAH
DRV/c or DRV/r	Dronedaron Ranolazine	Lovastatin Simvastatin	Rifampin Rifapentine <sup>d</sup>	None	Lurasidone Midazolam <sup>e</sup> Pimozide Triazolam	St. John's wort	Boceprevir Dasabuvir Ombitasvir Paritaprevir Simeprevir	Alfuzosin Cisapride <sup>f</sup> Ergot derivatives Salmeterol Sildenafil for PAH
FPV +/- RTV	Dronedaron Flecainide Propafenone Ranolazine	Lovastatin Simvastatin	Rifampin Rifapentine <sup>d</sup>	None	Lurasidone Midazolam <sup>e</sup> Pimozide Triazolam	St. John's wort	Boceprevir Dasabuvir Ombitasvir Paritaprevir Simeprevir	Alfuzosin Cisapride <sup>f</sup> Ergot derivatives Salmeterol Sildenafil for PAH
LPV/r	Dronedaron Ranolazine	Lovastatin Simvastatin	Rifampin <sup>g</sup> Rifapentine <sup>d</sup>	None	Lurasidone Midazolam <sup>e</sup> Pimozide Triazolam	St. John's wort	Boceprevir Dasabuvir Ombitasvir Paritaprevir Simeprevir	Alfuzosin Cisapride <sup>f</sup> Ergot derivatives Salmeterol Sildenafil for PAH
SQV/r	Amiodarone Dofetilide Dronedaron Flecainide Lidocaine Propafenone Quinidine Ranolazine	Lovastatin Simvastatin	Rifampin <sup>g</sup> Rifapentine <sup>d</sup>	None	Lurasidone Midazolam <sup>e</sup> Pimozide Trazodone Triazolam	Garlic supple- ments St. John's wort	Boceprevir Dasabuvir Ombitasvir Paritaprevir Simeprevir	Alfuzosin Cisapride <sup>f</sup> Ergot derivatives Salmeterol Sildenafil for PAH
TPV/r	Amiodarone Dronedaron Flecainide Propafenone Quinidine Ranolazine	Lovastatin Simvastatin	Rifampin Rifapentine <sup>d</sup>	None	Lurasidone Midazolam <sup>e</sup> Pimozide Triazolam	St. John's wort	Boceprevir Dasabuvir Ledipasvir Ombitasvir Paritaprevir Simeprevir Sofosbuvir	Alfuzosin Cisapride <sup>f</sup> Ergot derivatives Salmeterol Sildenafil for PAH
EFV	None	None	Rifapentine <sup>d</sup>	None	None	St. John's wort	Boceprevir Dasabuvir Ombitasvir Paritaprevir Simeprevir	None
ETR	None	None	Rifampin Rifapentine <sup>d</sup>	Carbamazepine Phenobarbital Phenytoin	None	St John's wort	Dasabuvir Ombitasvir Paritaprevir Simeprevir	Clopidogrel
NVP	None	None	Rifapentine <sup>d</sup>	None	None	St. John's wort	Dasabuvir Ombitasvir Paritaprevir Simeprevir	Ketoconazole

**Table 18. Drugs That Should Not Be Used With Antiretroviral Agents (Last updated April 8, 2015; last reviewed April 8, 2015) (page 2 of 2)**

This table only lists drugs that should not be coadministered at any dose, regardless of RTV or COBI enhancing. See Tables 19 and 20 for more detailed PK interaction data.

ARV Agents <sup>a,b</sup>	Cardiac Agents	Lipid-Lowering Agents	Antimycobacterial Agents	Anti-epileptic Agents	Neurologic Agents	Herbs	HCV Agents <sup>c</sup>	Other Agents
RPV	None	None	Rifampin Rifapentine <sup>d</sup>	Carbamazepine Oxcarbazepine Phenobarbital Phenytoin	None	St. John's wort	Dasabuvir Ombitasvir Paritaprevir	Proton pump inhibitors
MVC	None	None	Rifapentine <sup>d</sup>	None	None	St. John's wort	Dasabuvir Ombitasvir Paritaprevir	None
EVG/c/TDF/FTC or EVG + PI/r	Ranolazine	Lovastatin Simvastatin	Rifampin Rifapentine <sup>d</sup>	None	Lurasidone Pimozide Midazolam <sup>e</sup> Triazolam	St. John's wort	<u>EVG/c/TDF/FTC:</u> <ul style="list-style-type: none"> <li>• Boceprevir</li> <li>• Dasabuvir</li> <li>• Ledipasvir</li> <li>• Ombitasvir</li> <li>• Paritaprevir</li> <li>• Simeprevir</li> </ul> <u>EVG + PI/r:</u> <ul style="list-style-type: none"> <li>• Refer to agents listed for the selected PI</li> </ul>	Alfuzosin Cisapride <sup>f</sup> Ergot derivatives Salmeterol Sildenafil for PAH
DTG	Dofetilide	None	Rifapentine <sup>d</sup>	None	None	St. John's wort	None	None

<sup>a</sup> DLV, IDV, NFV, and RTV (as sole PI) are not included in this table. Refer to the appropriate FDA package insert for information regarding DLV-, IDV-, NFV-, and RTV (as sole PI)-related drug interactions.

<sup>b</sup> Certain listed drugs are contraindicated on the basis of theoretical considerations. Thus, drugs with narrow therapeutic indices and suspected metabolic involvement with CYP450 3A, 2D6, or unknown pathways are included in this table. Actual interactions may or may not occur in patients.

<sup>c</sup> HCV agents listed include only those that are commercially available at the publication of these guidelines.

<sup>d</sup> HIV-infected patients who received rifapentine as part of a treatment regimen for TB had a higher rate of TB relapse and acquired rifamycin resistance than those treated with other rifamycin-based regimens. Therefore an alternative agent to rifapentine is recommended for TB treatment.

<sup>e</sup> Use of oral midazolam is contraindicated. Single-dose parenteral midazolam can be used with caution and can be given in a monitored situation for procedural sedation.

<sup>f</sup> The manufacturer of cisapride has a limited-access protocol for patients who meet specific clinical eligibility criteria.

<sup>g</sup> A high rate of Grade 4 serum transaminase elevation was seen when a higher dose of RTV was added to LPV/r or SQV or when double-dose LPV/r was used with rifampin to compensate for rifampin's induction effect; therefore, these dosing strategies should not be used.

Suggested alternatives to:

- **Lovastatin, simvastatin:** Fluvastatin, pitavastatin, and pravastatin (except for pravastatin with DRV/r) have the least potential for drug-drug interactions (see Table 19a). Use atorvastatin and rosuvastatin with caution; start with the lowest possible dose and titrate based on tolerance and lipid-lowering efficacy.
- **Rifampin:** Rifabutin (with dosage adjustment, see Tables 19a and 19b)
- **Midazolam, triazolam:** temazepam, lorazepam, oxazepam

**Key to Acronyms:** ARV = antiretroviral; ATV = atazanavir; COBI = cobicistat; CYP = cytochrome P; DLV = delavirdine; DRV/c = darunavir/cobicistat; DRV/r = darunavir/ritonavir; DTG = dolutegravir; EFV = efavirenz; ETR = etravirine; EVG = elvitegravir; EVG/c/TDF/FTC = elvitegravir/cobicistat/tenofovir/emtricitabine; FDA = Food and Drug Administration; FPV = fosamprenavir; FTC = emtricitabine; HCV = hepatitis C virus; IDV = indinavir; LPV/r = lopinavir/ritonavir; MVC = maraviroc; NFV = nelfinavir; NVP = nevirapine; PAH = pulmonary arterial hypertension; PI = protease inhibitor; PI/r = ritonavir-boosted protease inhibitor; PK = pharmacokinetic; RPV = rilpivirine; RTV = ritonavir; SQV = saquinavir; SQV/r = saquinavir/ritonavir; TB = tuberculosis; TDF = tenofovir disoproxil fumarate; TPV/r = tipranavir/ritonavir



**Table 19a. Drug Interactions Between Protease Inhibitors and Other Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 1 of 14)**

This table provides known or predicted information regarding PK interactions between PIs and non-ARV drugs. When information is available, interactions for specific pharmacologically-boosted (with either RTV or COBI) and unboosted PIs are listed separately. The term “All PIs” refers to both unboosted and pharmacologically-boosted PI products. For interactions between ARV agents and for dosing recommendations, refer to Tables [19c](#), [20a](#), and [20b](#).

**Note:** NFV and IDV are **not** included in this table. Please refer to the FDA product labels for NFV and IDV for information regarding drug interactions with these PIs.

Concomitant Drug	PI	Effect on PI and/or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>Acid Reducers</b>			
<b>Antacids</b>	ATV, ATV/c, ATV/r	When given simultaneously, ↓ ATV expected	Give ATV at least 2 hours before or 1 to 2 hours after antacids or buffered medications.
	FPV	APV AUC ↓ 18%; ↔ in APV C <sub>min</sub>	Give FPV simultaneously with (or at least 2 hours before or 1 hour after) antacids.
	TPV/r	TPV AUC ↓ 27%	Give TPV at least 2 hours before or 1 hour after antacids.
<b>H2 Receptor Antagonists</b>	ATV (unboosted)	↓ ATV	H2 receptor antagonist single dose should not exceed a dose equivalent to famotidine 20 mg and the total daily dose should not exceed a dose equivalent to famotidine 20 mg BID in ART-naïve patients.  Give ATV at least 2 hours before and at least 10 hours after the H2 receptor antagonist.
	ATV/c, ATV/r	↓ ATV	H2 receptor antagonist dose should not exceed a dose equivalent to famotidine 40 mg BID in ART-naïve patients or 20 mg BID in ART-experienced patients.  Give ATV 300 mg plus COBI 150 mg or RTV 100 mg simultaneously with and/or ≥10 hours after the dose of H2 receptor antagonist.  If using TDF and H2 receptor antagonist in ART-experienced patients, use ATV 400 mg plus COBI 150 mg or RTV 100 mg.
	DRV/c, DRV/r, LPV/r	No significant effect shown or expected	No dosage adjustment necessary.
	FPV (unboosted)	APV AUC ↓ 30%; no significant change in APV C <sub>min</sub>	If concomitant use is necessary, give FPV at least 2 hours before H2 receptor antagonist. Consider boosting FPV with RTV.
<b>PPIs</b>	ATV (unboosted)	↓ ATV	<b>PPIs are not recommended in patients receiving unboosted ATV.</b> In these patients, consider alternative acid-reducing agents, RTV or COBI boosting, or alternative PIs.
	ATV/c, ATV/r	↓ ATV	PPIs should not exceed a dose equivalent to omeprazole 20 mg daily in PI-naïve patients. PPIs should be administered at least 12 hours before ATV/c or ATV/r.  <b>PPIs are not recommended in PI-experienced patients.</b>
	DRV/r	omeprazole AUC ↓ 42%	No dosage adjustment necessary.
	DRV/c	No significant effect expected	No dosage adjustment necessary.
	FPV, FPV/r, LPV/r	No significant effect	No dosage adjustment necessary.
	SQV/r	SQV AUC ↑ 82%	Monitor for SQV toxicities.
	TPV/r	↓ omeprazole	May need to increase omeprazole dose.

**Table 19a. Drug Interactions between Protease Inhibitors and Other Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 2 of 14)**

Concomitant Drug	PI	Effect on PI and/or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>Anticoagulants and Antiplatelets</b>			
<b>Apixaban</b>	All PIs	↑ apixaban expected	<b>Avoid concomitant use.</b>
<b>Dabigatran</b>	All RTV-boosted PIs, ATV/c, DRV/c	↑ dabigatran possible	No dosage adjustment if CrCl > 50 mL/min. <b>Avoid coadministration if CrCl &lt; 50 mL/min.</b>
<b>Rivaroxaban</b>	All PIs	↑ rivaroxaban	<b>Avoid concomitant use.</b>
<b>Ticagrelor</b>	All PIs	↑ ticagrelor expected	<b>Avoid concomitant use.</b>
<b>Vorapaxar</b>	All PIs	↑ vorapaxar expected	<b>Avoid concomitant use.</b>
<b>Warfarin</b>	PI/r	↓ warfarin possible	Monitor INR closely when stopping or starting PI/r and adjust warfarin dose accordingly.
	ATV/c, DRV/c	No data	Monitor INR closely when stopping or starting PI/c and adjust warfarin dose accordingly.  If switching between RTV and COBI, the effect of COBI on warfarin is not expected to be equivalent to RTV's effect on warfarin.
<b>Anticonvulsants</b>			
<b>Carbamazepine</b>	ATV, FPV (unboosted)	May ↓ PI levels substantially	<b>Do not coadminister.</b> Consider alternative anticonvulsant or ATV/r, ATV/c, or FPV/r.
	ATV/c, ATV/r, DRV/c, FPV/r, LPV/r, SQV/r, TPV/r	↑ carbamazepine possible TPV/r ↑ carbamazepine AUC 26% May ↓ PI levels substantially	Consider alternative anticonvulsant or monitor levels of both drugs and assess virologic response. <b>Do not coadminister with LPV/r or FPV/r once daily.</b>
	DRV/r	carbamazepine AUC ↑ 45% DRV: no significant change	Monitor anticonvulsant level and adjust dose accordingly.
<b>Ethosuximide</b>	All PIs	↑ ethosuximide possible	Clinically monitor for ethosuximide toxicities.
<b>Lamotrigine</b>	ATV (unboosted)	lamotrigine: no effect	No dose adjustment necessary.
	ATV/r	lamotrigine AUC ↓ 32%	A dose increase of lamotrigine may be needed; consider monitoring lamotrigine concentration or consider alternative anticonvulsant.
	LPV/r	lamotrigine AUC ↓ 50% LPV: no significant change	
	PI/r (other than ATV/r or LPV/r)	↓ lamotrigine possible	
	ATV/c, DRV/c	No data	Monitor lamotrigine concentration or consider alternative anticonvulsant.

**Table 19a. Drug Interactions between Protease Inhibitors and Other Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 3 of 14)**

Concomitant Drug	PI	Effect on PI and/or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>Anticonvulsants, continued</b>			
<b>Phenobarbital</b>	All PIs	May ↓ PI levels substantially	Consider alternative anticonvulsant or monitor levels of both drugs and assess virologic response.  <b>Do not coadminister with LPV/r or FPV/r once daily, or unboosted ATV or FPV.</b>
<b>Phenytoin</b>	ATV, FPV (unboosted)	May ↓ PI levels substantially	<b>Do not coadminister.</b> Consider alternative anticonvulsant or boosting either ATV or FPV.
	ATV/r, DRV/r, SQV/r, TPV/r	↓ phenytoin possible ↓ PI possible	Consider alternative anticonvulsant or monitor levels of both drugs and assess virologic response.
	ATV/c, DRV/c	Effect on phenytoin unknown ↓ PI possible	
	FPV/r	phenytoin AUC ↓ 22% APV AUC ↑ 20%	Monitor phenytoin level and adjust dose accordingly. No change in FPV/r dose recommended.
	LPV/r	phenytoin AUC ↓ 31% LPV/r AUC ↓ 33%	Consider alternative anticonvulsant or monitor levels of both drugs and assess virologic response.  <b>Do not coadminister with LPV/r once daily.</b>
<b>Valproic Acid</b>	LPV/r	↓ or ↔ VPA possible LPV AUC ↑ 75%	Monitor VPA levels and virologic response. Monitor for LPV-related toxicities.
<b>Antidepressants, Anxiolytics, and Antipsychotics (Also see Sedative/Hypnotics section below.)</b>			
<b>Bupropion</b>	LPV/r	bupropion AUC ↓ 57%	Titrate bupropion dose based on clinical response.
	TPV/r	bupropion AUC ↓ 46%	
<b>Buspirone</b>	All PIs	↑ buspirone expected	Use a low dose of buspirone with caution and titrate buspirone dose based on clinical response.
<b>Fluvoxamine</b>	All PIs	↑ or ↓ PI possible	Consider alternative therapeutic agent.
<b>Other Selective Serotonin Reuptake Inhibitors (SSRIs) (e.g., citalopram, escitalopram, fluoxetine, paroxetine, sertraline)</b>	RTV	escitalopram ↔	Titrate SSRI dose based on clinical response.
	DRV/r	paroxetine AUC ↓ 39% sertraline AUC ↓ 49%	
	FPV/r	paroxetine AUC ↓ 55%	
	ATV/r, LPV/r, SQV/r, TPV/r	No data	
	ATV/c, DRV/c	Effects unknown	Titrate SSRI dose using the lowest available initial or maintenance dose.

**Table 19a. Drug Interactions between Protease Inhibitors and Other Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 4 of 14)**

Concomitant Drug	PI	Effect on PI and/or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>Antidepressants, Anxiolytics, and Antipsychotics (Also see Sedative/Hypnotics section below.), continued</b>			
<b>Quetiapine</b>	All PIs	↑ quetiapine expected	<p><u>Starting quetiapine in a patient receiving a PI:</u></p> <ul style="list-style-type: none"> <li>• Start quetiapine at the lowest dose and titrate up as needed. Monitor for quetiapine effectiveness and adverse effects.</li> </ul> <p><u>Starting a PI in a patient receiving a stable dose of quetiapine:</u></p> <ul style="list-style-type: none"> <li>• Reduce quetiapine dose to 1/6 of the original dose. Closely monitor for quetiapine effectiveness and adverse effects.</li> </ul>
<b>Trazodone</b>	All PIs except SQV/r	RTV 200 mg BID (for 2 days) ↑ trazodone AUC 240%	Use lowest dose of trazodone and monitor for CNS and cardiovascular adverse effects.
	SQV/r	↑ trazodone expected	<b>Contraindicated. Do not coadminister.</b>
<b>Tricyclic Antidepressants</b> Amitriptyline, Desipramine, Doxepin, Imipramine, Nortriptyline	All RTV-boosted PIs, ATV/c, DRV/c	↑ TCA expected	Use lowest possible TCA dose and titrate based on clinical assessment and/or drug levels.
<b>Antifungals</b>			
<b>Fluconazole</b>	ATV/c, ATV/r	No significant effect observed or expected	No dosage adjustment necessary.
	SQV/r	No data with RTV boosting	No dosage adjustment necessary.
	TPV/r	TPV AUC ↑ 50%	Fluconazole >200 mg daily is not recommended. If high-dose fluconazole is indicated, consider alternative ARV.
<b>Itraconazole</b>	All PIs	↑ itraconazole possible ↑ PI possible	Consider monitoring itraconazole level to guide dosage adjustments. Doses >200 mg/day are not recommended with RTV-boosted PIs, ATV/c, or DRV/c unless dosing is guided by itraconazole levels.
<b>Posaconazole</b>	ATV/c	↑ ATV possible	Monitor for adverse effects of ATV.
	ATV/r	ATV AUC ↑ 146%	
	ATV	ATV AUC ↑ 268%	
	FPV	With FPV 700 mg BID (without RTV): posaconazole AUC ↓ 23%, APV AUC similar to that with FPV 1400 mg BID With FPV 1400 mg BID: ↑ APV expected	If coadministered, monitor posaconazole concentrations.
	DRV/c, DRV/r, FPV/r, LPV/r, SQV/r, TPV/r	↑ PI possible ↑ posaconazole possible	If coadministered, consider monitoring posaconazole concentrations. Monitor for PI adverse effects.

**Table 19a. Drug Interactions between Protease Inhibitors and Other Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 5 of 14)**

Concomitant Drug	PI	Effect on PI and/or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>Antifungals, continued</b>			
<b>Voriconazole</b>	ATV, FPV (unboosted)	↑ voriconazole possible ↑ PI possible	Monitor for toxicities.
	All RTV-boosted PIs	RTV 400 mg BID ↓ voriconazole AUC 82% RTV 100 mg BID ↓ voriconazole AUC 39%	<b>Do not coadminister voriconazole and RTV or COBI unless benefit outweighs risk.</b> If coadministered, consider monitoring voriconazole concentration and adjust dose accordingly.
	ATV/c, DRV/c	Effects unknown	
<b>Antimalarials</b>			
<b>Artemether/ Lumefantrine</b>	DRV/r	artemether AUC ↓ 16% DHA <sup>a</sup> AUC ↓ 18% lumefantrine AUC ↑ 2.5-fold	Clinical significance unknown. If used, monitor closely for anti-malarial efficacy and lumefantrine toxicity.
	DRV/c	↑ lumefantrine expected effect on artemether unknown	
	LPV/r	artemether AUC ↓ 40% DHA AUC ↓ 17% lumefantrine AUC ↑ 470%	
<b>Atovaquone/ Proguanil</b>	ATV/r, LPV/r	ATV/r ↓ atovaquone AUC 46% and ↓ proguanil AUC 41%  LPV/r ↓ atovaquone AUC 74% and ↓ proguanil AUC 38%	No dosage recommendation. Consider alternative drug for malaria prophylaxis, if possible.
<b>Mefloquine</b>	RTV	With RTV 200 mg BID: RTV AUC ↓ 31%, C <sub>min</sub> ↓ 43%; ⇌ mefloquine	Use with caution. Effect on exposure of RTV-boosted PIs is unknown.
<b>Antimycobacterials</b>			
<b>Bedaquiline</b>	All RTV-boosted PIs, ATV/c, DRV/c	With LPV/r: bedaquiline AUC ↑ 22%, C <sub>max</sub> ⇌  With other PI/r, ATV/c, or DRV/c: ↑ bedaquiline possible	Clinical significance unknown. Use with caution if benefit outweighs the risk and monitor for QTc prolongation and liver function tests.
<b>Clarithromycin</b>	ATV/r, ATV	clarithromycin AUC ↑ 94%	May cause QTc prolongation. Reduce clarithromycin dose by 50%. Consider alternative therapy (e.g., azithromycin).
	ATV/c, DRV/c	↑ clarithromycin expected	Consider alternative macrolide (e.g., azithromycin)
	DRV/r, FPV/r, LPV/r, SQV/r, TPV/r	DRV/r ↑ clarithromycin AUC 57% FPV/r ↑ clarithromycin possible LPV/r ↑ clarithromycin expected RTV 500 mg BID ↑ clarithromycin 77% SQV unboosted ↑ clarithromycin 45% TPV/r ↑ clarithromycin 19% clarithromycin ↑ unboosted SQV 177% clarithromycin ↑ TPV 66%	Monitor for clarithromycin-related toxicities or consider alternative macrolide (e.g., azithromycin).  Reduce clarithromycin dose by 50% in patients with CrCl 30–60 mL/min.  Reduce clarithromycin dose by 75% in patients with CrCl <30 mL/min.
	FPV	APV AUC ↑ 18%	No dosage adjustment necessary.



**Table 19a. Drug Interactions between Protease Inhibitors and Other Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 6 of 14)**

Concomitant Drug	PI	Effect on PI and/or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>Antimycobacterials (for treatment of <i>Mycobacterium tuberculosis</i> and non-tuberculosis mycobacterial infections), continued</b>			
<b>Rifabutin</b>	ATV (unboosted)	↑ rifabutin AUC expected	Rifabutin 150 mg daily or 300 mg three times a week
	FPV (unboosted)	No data	Consider alternative ARV.
	ATV/c, DRV/c	↑ rifabutin expected	Rifabutin 150 mg once daily or 300 mg three times a week. Monitor for antimycobacterial activity and consider therapeutic drug monitoring.  PK data reported in this table are results from healthy volunteer studies. Lower rifabutin exposure has been reported in HIV-infected patients than in the healthy study participants.
	ATV/r	Compared with rifabutin (300 mg once daily) alone, rifabutin (150 mg once daily) with ATV/r, rifabutin AUC ↑ 110% and metabolite AUC ↑ 2101%	
	DRV/r	Compared with rifabutin (300 mg once daily) alone, rifabutin (150 mg every other day) with DRV/r, rifabutin AUC ↔ and metabolite AUC ↑ 881%	
	FPV/r	Compared with rifabutin (300 mg once daily) alone, rifabutin (150 mg every other day) with FPV/r, rifabutin and metabolite AUC ↑ 64%.	
	LPV/r	Compared with rifabutin (300 mg daily) alone, rifabutin (150 mg once daily) with LPV/r, rifabutin and metabolite AUC ↑ 473%.	
	SQV/r	↑ rifabutin with unboosted SQV	
	TPV/r	rifabutin and metabolite AUC ↑ 333%	
<b>Rifampin</b>	All PIs	↓ PI concentration by >75%	<b>Do not coadminister rifampin and PIs.</b> Additional RTV does not overcome this interaction and increases hepatotoxicity. Additional COBI is not recommended. Consider rifabutin if a rifamycin is indicated.
<b>Rifapentine</b>	All PIs	↓ PI expected	<b>Do not coadminister.</b>
<b>Cardiac Medications</b>			
<b>Amiodarone</b>	SQV/r, TPV/r	↑ both amiodarone and PI possible	<b>Do not coadminister.</b>
	All PIs (except SQV/r, TPV/r)	↑ both amiodarone and PI possible	Use with caution. Monitor for amiodarone toxicity and consider ECG and amiodarone drug level monitoring.
<b>Antiarrhythmics</b> (e.g., dofetilide, dronedarone, flecainide, lidocaine, propafenone, quinidine)	SQV/r	↑ antiarrhythmic possible	<b>Do not coadminister.</b>
	All PIs	↑ antiarrhythmic possible	Use with caution. Refer to <a href="#">Table 18</a> for contraindicated combinations.

**Table 19a. Drug Interactions between Protease Inhibitors and Other Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 7 of 14)**

Concomitant Drug	PI	Effect on PI and/or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>Cardiac Medications, continued</b>			
<b>Beta-blockers</b> (e.g., metoprolol, timolol)	All PIs	↑ beta-blockers possible	May need to decrease beta-blocker dose; adjust dose based on clinical response.  Consider using beta-blockers that are not metabolized by CYP450 enzymes (e.g., atenolol, labetalol, nadolol, sotalol).
<b>Bosentan</b>	All PIs	LPV/r ↑ bosentan 48-fold (day 4) and 5-fold (day 10)  ↓ ATV expected	<b>Do not coadminister bosentan and unboosted ATV.</b>  <u>In Patients on a PI (Other than Unboosted ATV) &gt;10 Days:</u> • Start bosentan at 62.5 mg once daily or every other day.  <u>In Patients on Bosentan who Require a PI (Other than Unboosted ATV):</u> • Stop bosentan ≥36 hours before PI initiation and 10 days after PI initiation restart bosentan at 62.5 mg once daily or every other day.  <u>When switching between COBI and RTV:</u> • Maintain same bosentan dose.
<b>Calcium Channel Blockers (CCBs)</b> (except diltiazem)	All PIs	↑ dihydropyridine possible  ↑ verapamil possible	Use with caution. Titrate CCB dose and monitor closely. ECG monitoring is recommended when CCB used with ATV and SQV.
<b>Digoxin</b>	PI/r, ATV/c, or DRV/c	RTV (200 mg BID) ↑ digoxin AUC 29% and ↑ half-life 43%  SQV/r ↑ digoxin AUC 49%  DRV/r ↑ digoxin AUC 36%  COBI ↑ digoxin C <sub>max</sub> 41%, AUC ↔	Use with caution. Monitor digoxin levels. Digoxin dose may need to be decreased. Titrate initial digoxin dose.
<b>Diltiazem</b>	ATV/c, ATV/r, ATV	Unboosted ATV ↑ diltiazem AUC 125%  Greater ↑ likely with ATV/c or ATV/r	Decrease diltiazem dose by 50%. ECG monitoring is recommended.
	DRV/c, DRV/r, FPV/r, FPV, LPV/r, SQV/r, TPV/r	↑ diltiazem possible	Use with caution. Adjust diltiazem according to clinical response and toxicities.
<b>Corticosteroids</b>			
<b>Beclomethasone</b> Inhaled	DRV/r	RTV 100 mg BID ↑ 17-BMP AUC 2-fold and ↑ C <sub>max</sub> 1.6-fold  (DRV 600 mg + RTV 100 mg) BID ↓ 17-BMP AUC 11% and ↓ C <sub>max</sub> 19%	No dosage adjustment necessary.  Significant interaction between beclomethasone (inhaled or intranasal) and other RTV-boosted PIs, ATV/c, or DRV/c is not expected.
<b>Budesonide</b> Systemic	All PIs	↓ PI levels possible  ↑ glucocorticoids	Coadministration can result in adrenal insufficiency and Cushing's syndrome. <b>Do not coadminister unless potential benefits of systemic budesonide outweigh the risks of systemic corticosteroid adverse effects.</b>

**Table 19a. Drug Interactions between Protease Inhibitors and Other Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 8 of 14)**

Concomitant Drug	PI	Effect on PI and/or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>Corticosteroids, continued</b>			
<b>Budesonide, Fluticasone, Mometasone</b> Inhaled or Intranasal	All RTV- or COBI-boosted PIs	↑ glucocorticoids possible RTV 100 mg BID ↑ fluticasone AUC 350-fold and ↑ C <sub>max</sub> 25-fold	Coadministration can result in adrenal insufficiency and Cushing's syndrome. <b>Do not coadminister unless potential benefits of inhaled or intranasal corticosteroid outweigh the risks of systemic corticosteroid adverse effects.</b> Consider alternative corticosteroid (e.g., beclomethasone).
<b>Dexamethasone</b> Systemic	All PIs	↓ PI levels possible	Use systemic dexamethasone with caution. Consider alternative corticosteroid for long-term use.
<b>Prednisone</b>	LPV/r	↑ prednisolone AUC 31%	Use with caution. Coadministration can result in adrenal insufficiency and Cushing's syndrome. <b>Do not coadminister unless potential benefits of prednisone outweigh the risks of systemic corticosteroid adverse effects.</b>
	All PIs	↑ prednisolone possible	
<b>Methyl-prednisolone, Prednisolone, Triamcinolone</b> (local injections, including intra-articular, epidural, intra-orbital)	All RTV- or COBI-boosted PIs	↑ glucocorticoids expected	<b>Do not coadminister.</b> Coadministration can result in adrenal insufficiency and Cushing's syndrome.
<b>Hepatitis C Direct-Acting Antiviral Agents</b>			
<b>Boceprevir</b>	ATV/r	ATV AUC ↓ 35%, C <sub>min</sub> ↓ 49% boceprevir AUC ↔	<b>Do not coadminister.</b>
	ATV/c, DRV/c	Effects unknown	<b>Do not coadminister.</b>
	DRV/r	DRV AUC ↓ 44%, C <sub>min</sub> ↓ 59% boceprevir AUC ↓ 32%, C <sub>min</sub> ↓ 35%	<b>Do not coadminister.</b>
	LPV/r	LPV AUC ↓ 34%, C <sub>min</sub> ↓ 43% boceprevir AUC ↓ 45%, C <sub>min</sub> ↓ 57%	<b>Do not coadminister.</b>
<b>Dasabuvir + Paritaprevir/ Ombitasvir/RTV</b>	ATV	ATV ↔	ATV 300 mg alone, <b>without COBI or additional RTV</b> , should be given in the morning with dasabuvir + paritaprevir/ ombitasvir/RTV.
	DRV	DRV C <sub>min</sub> ↓ 43% to 48%	<b>Do not coadminister.</b>
	LPV/r	paritaprevir AUC ↑ 117%	<b>Do not coadminister.</b>
	ATV/c, DRV/c, FPV, SQV, TPV	No data	<b>Do not coadminister.</b>

**Table 19a. Drug Interactions between Protease Inhibitors and Other Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 9 of 14)**

Concomitant Drug	PI	Effect on PI and/or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>Hepatitis C Direct-Acting Antiviral Agents, continued</b>			
<b>Ledipasvir/ Sofosbuvir</b>	ATV/r	ATV AUC ↑ 33% ledipasvir AUC ↑ 113% sofosbuvir: no significant effect	No dosage adjustment necessary.
	DRV/r	DRV: no significant effect expected ledipasvir/sofosbuvir: no significant effect	Coadministration of ledipasvir/sofosbuvir with TDF and a PI/r results in increased exposure to TDF. The safety of the increased TDF exposure has not been established. Consider alternative HCV or ARV drugs to avoid increased TDF toxicities. If coadministration is necessary, monitor for TDF-associated adverse reactions.
	ATV/c, DRV/c, FPV, FPV/r, LPV/r, SQV/r	No significant effect expected	
	TPV/r	↓ ledipasvir and sofosbuvir expected	<b>Do not coadminister.</b>
<b>Simeprevir</b>	All PIs	Compared with simeprevir 150 mg alone, simeprevir 50 mg plus DRV/r 800/100 mg daily, simeprevir AUC ↑ 159%  RTV 100 mg BID ↑ simeprevir AUC 618%	<b>Do not coadminister.</b>
<b>Herbal Products</b>			
<b>St. John's Wort</b>	All PIs	↓ PI expected	<b>Do not coadminister.</b>
<b>Hormonal Contraceptives</b>			
<b>Hormonal Contraceptives (oral)</b>	ATV (unboosted)	ethinyl estradiol AUC ↑ 48% norethindrone AUC ↑ 110%	Prescribe oral contraceptive that contains no more than 30 mcg of ethinyl estradiol or recommend alternative contraceptive method.  Oral contraceptives containing less than 25 mcg of ethinyl estradiol or progestins other than norethindrone or norgestimate have not been studied. <sup>c</sup>
	ATV/r	ethinyl estradiol AUC ↓ 19% and C <sub>min</sub> ↓ 37% norgestimate ↑ 85%	Oral contraceptive should contain at least 35 mcg of ethinyl estradiol.  Oral contraceptives containing progestins other than norethindrone or norgestimate have not been studied. <sup>b</sup>
	ATV/c, DRV/c	Effects unknown	Recommend alternative or additional contraceptive method or alternative ARV drug.
	DRV/r, FPV/r, LPV/r, SQV/r, TPV/r	ethinyl estradiol AUC ↓ 37% to 48% norethindrone AUC ↓ 14% to 34% With TPV/r: norethindrone AUC ↔	Recommend alternative or additional contraceptive method or alternative ARV drug.
	FPV	With APV: ↑ ethinyl estradiol and ↑ norethindrone C <sub>min</sub> ; APV C <sub>min</sub> ↓ 20%	Recommend alternative contraceptive method or alternative ARV drug.
<b>Etonogestrel-releasing subdermal implant</b>	LPV/r	etonogestrel AUC ↑ 52% and C <sub>min</sub> ↑ 34%	Use standard dose.
	All other PIs	No data	Recommend alternative or additional contraceptive method or alternative ARV drug.

**Table 19a. Drug Interactions between Protease Inhibitors and Other Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 10 of 14)**

Concomitant Drug	PI	Effect on PI and/or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>Hormonal Contraceptives, continued</b>			
<b>Transdermal ethinyl estradiol/norelgestromin</b>	LPV/r	LPV ↔ ethinyl estradiol AUC ↓ 45%, norelgestromin AUC ↑ 83%	Use standard dose.
	All other PIs	No data	Recommend alternative or additional contraceptive method or alternative ARV drug.
<b>HMG-CoA Reductase Inhibitors</b>			
<b>Atorvastatin</b>	ATV, ATV/c, ATV/r, DRV/c	↑ atorvastatin possible	Titrate atorvastatin dose carefully and use lowest dose necessary.
	DRV/r	DRV/r plus atorvastatin 10 mg similar to atorvastatin 40 mg administered alone	Titrate atorvastatin dose carefully and use the lowest necessary dose. Do not exceed 20 mg atorvastatin daily.
	FPV, FPV/r,	FPV +/- RTV ↑ atorvastatin AUC 130% to 153%	
	SQV/r	SQV/r ↑ atorvastatin AUC 79%	
	LPV/r	LPV/r ↑ atorvastatin AUC 488%	Use with caution and use the lowest atorvastatin dose necessary.
	TPV/r	↑ atorvastatin AUC 836%	<b>Do not coadminister.</b>
<b>Lovastatin</b>	All PIs	Significant ↑ lovastatin expected	<b>Contraindicated. Do not coadminister.</b>
<b>Pitavastatin</b>	All PIs	ATV ↑ pitavastatin AUC 31%, C <sub>max</sub> ↑ 60%  ATV: no significant effect DRV/r: no significant effect LPV/r ↓ pitavastatin AUC 20% LPV: no significant effect	No dose adjustment necessary.
<b>Pravastatin</b>	ATV/c, ATV/r	No data	Use lowest starting dose of pravastatin and monitor for efficacy and adverse effects.
	DRV/c, DRV/r	With DRV/r, pravastatin AUC • ↑ 81% following single dose of pravastatin • ↑ 23% at steady state	Use lowest possible starting dose of pravastatin with careful monitoring.
	LPV/r	pravastatin AUC ↑ 33%	No dose adjustment necessary.
	SQV/r	pravastatin AUC ↓ 47% to 50%	No dose adjustment necessary.



**Table 19a. Drug Interactions between Protease Inhibitors and Other Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 11 of 14)**

Concomitant Drug	PI	Effect on PI and/or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>HMG-CoA Reductase Inhibitors, continued</b>			
<b>Rosuvastatin</b>	ATV/c, DRV/c	↑ rosuvastatin possible	Titrate rosuvastatin dose carefully and use the lowest necessary dose while monitoring for toxicities.
	ATV/r, LPV/r	ATV/r ↑ rosuvastatin AUC 3-fold and C <sub>max</sub> ↑ 7-fold LPV/r ↑ rosuvastatin AUC 108% and C <sub>max</sub> ↑ 366%	Titrate rosuvastatin dose carefully and use the lowest necessary dose. Do not exceed 10 mg rosuvastatin daily.
	DRV/r	rosuvastatin AUC ↑ 48% and C <sub>max</sub> ↑ 139%	Titrate rosuvastatin dose carefully and use the lowest necessary dose while monitoring for toxicities.
	FPV +/- RTV	No significant effect on rosuvastatin	No dosage adjustment necessary.
	SQV/r	No data available	Titrate rosuvastatin dose carefully and use the lowest necessary dose while monitoring for toxicities.
	TPV/r	rosuvastatin AUC ↑ 26% and C <sub>max</sub> ↑ 123%	No dosage adjustment necessary.
<b>Simvastatin</b>	All PIs	Significant ↑ simvastatin level: SQV/r 400 mg/400 mg BID ↑ simvastatin AUC 3059%	<b>Contraindicated. Do not coadminister.</b>
<b>Immunosuppressants</b>			
<b>Cyclosporine Everolimus Sirolimus Tacrolimus</b>	All PIs	↑ immunosuppressant expected	Initiate with an adjusted dose of immunosuppressant to account for potential increased concentrations of the immunosuppressant and monitor for toxicities. Therapeutic drug monitoring of immunosuppressant is recommended. Consult with specialist as necessary.
<b>Narcotics and Treatment for Opioid Dependence</b>			
<b>Buprenorphine</b>	ATV (unboosted)	buprenorphine AUC ↑ 93% norbuprenorphine <sup>d</sup> AUC ↑ 76% ↓ ATV possible	<b>Do not coadminister buprenorphine with unboosted ATV.</b>
	ATV/r	buprenorphine AUC ↑ 66% norbuprenorphine <sup>d</sup> AUC ↑ 105%	Monitor for sedation. Buprenorphine dose reduction may be necessary.
	ATV/c, DRV/c	Effects unknown	Titrate buprenorphine dose using the lowest initial dose. Dose adjustment of buprenorphine may be needed. Clinical monitoring is recommended.
	DRV/r	buprenorphine: no significant effect norbuprenorphine <sup>d</sup> AUC ↑ 46% and C <sub>min</sub> ↑ 71%	No dosage adjustment necessary. Clinical monitoring is recommended.
	FPV/r	buprenorphine: no significant effect norbuprenorphine <sup>d</sup> AUC ↓ 15%	No dosage adjustment necessary. Clinical monitoring is recommended.
	LPV/r	No significant effect	No dosage adjustment necessary.
	TPV/r	buprenorphine: no significant effect norbuprenorphine <sup>d</sup> AUC, C <sub>max</sub> , and C <sub>min</sub> ↓ 80% TPV C <sub>min</sub> ↓ 19% to 40%	Consider monitoring TPV level.

**Table 19a. Drug Interactions between Protease Inhibitors and Other Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 12 of 14)**

Concomitant Drug	PI	Effect on PI and/or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>Narcotics and Treatment for Opioid Dependence, continued</b>			
<b>Fentanyl</b>	All PIs	↑ fentanyl possible	Clinical monitoring is recommended, including for potentially fatal respiratory depression.
<b>Methadone</b>	ATV (unboosted)	No significant effect	No dosage adjustment necessary.
	ATV/c, DRV/c	Effects unknown	Titrate methadone dose using the lowest feasible initial dose. Dose adjustment of methadone may be needed. Clinical monitoring is recommended.
	FPV (unboosted)	No data with unboosted FPV APV ↓ R-methadone <sup>e</sup> C <sub>min</sub> 21%, AUC no significant change	Monitor and titrate methadone as clinically indicated. The interaction with FPV is presumed to be similar to that with APV.
	RTV-boosted PIs	ATV/r, DRV/r, and FPV/r ↓ R-methadone <sup>e</sup> AUC 16% to 18% LPV/r ↓ methadone AUC 26% to 53% SQV/r 1000/100 mg BID ↓ R-methadone <sup>e</sup> AUC 19% TPV/r ↓ R-methadone <sup>e</sup> AUC 48%	Opioid withdrawal unlikely but may occur. Dosage adjustment of methadone is not usually required, but monitor for opioid withdrawal and increase methadone dose as clinically indicated.
<b>Oxycodone</b>	LPV/r	oxycodone AUC ↑ 2.6-fold	Monitor for opioid-related adverse effects. Oxycodone dose reduction may be necessary.
<b>Phosphodiesterase Type 5 (PDE5) Inhibitors</b>			
<b>Avanafil</b>	All PIs except unboosted FPV	RTV (600 mg BID for 5 days) ↑ avanafil AUC 13-fold, C <sub>max</sub> 2.4-fold	<b>Coadministration is not recommended.</b>
	ATV, FPV (unboosted)	No data	Avanafil dose should not exceed 50 mg once every 24 hours.
<b>Sildenafil</b>	All PIs	DRV/r plus sildenafil 25 mg similar to sildenafil 100 mg alone RTV 500 mg BID ↑ sildenafil AUC 1,000% SQV unboosted ↑ sildenafil AUC 210%	<u>For Treatment of Erectile Dysfunction:</u> • Start with sildenafil 25 mg every 48 hours and monitor for adverse effects of sildenafil. <u>For Treatment of PAH:</u> • <b>Contraindicated</b>

**Table 19a. Drug Interactions between Protease Inhibitors and Other Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 13 of 14)**

Concomitant Drug	PI	Effect on PI and/or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>Phosphodiesterase Type 5 (PDE5) Inhibitors, continued</b>			
<b>Tadalafil</b>	All PIs	RTV 200 mg BID ↑ tadalafil AUC 124% TPV/r (1st dose) ↑ tadalafil AUC 133% TPV/r steady state: no significant effect	<u>For Treatment of Erectile Dysfunction:</u> • Start with tadalafil 5-mg dose and do not exceed a single dose of 10 mg every 72 hours. Monitor for adverse effects of tadalafil. <u>For Treatment of PAH</u> <i>In patients on a PI &gt;7 days:</i> • Start with tadalafil 20 mg once daily and increase to 40 mg once daily based on tolerability. <i>In patients on tadalafil who require a PI:</i> • Stop tadalafil ≥24 hours before PI initiation. 7 days after PI initiation restart tadalafil at 20 mg once daily, and increase to 40 mg once daily based on tolerability. <i>In patients switching between COBI and RTV:</i> • Maintain tadalafil dose. <u>For Treatment of Benign Prostatic Hyperplasia:</u> • Maximum recommended daily dose is 2.5 mg per day.
<b>Vardenafil</b>	All PIs	RTV 600 mg BID ↑ vardenafil AUC 49-fold	Start with vardenafil 2.5 mg every 72 hours and monitor for adverse effects of vardenafil.
<b>Sedative/Hypnotics</b>			
<b>Alprazolam</b> <b>Diazepam</b>	All PIs	↑ benzodiazepine possible RTV (200 mg BID for 2 days) ↑ alprazolam half-life 222% and AUC 248%	Consider alternative benzodiazepines such as lorazepam, oxazepam, or temazepam.
<b>Lorazepam</b> <b>Oxazepam</b> <b>Temazepam</b>	All PIs	No data	These benzodiazepines are metabolized via non-CYP450 pathways; thus, there is less interaction potential than with other benzodiazepines.
<b>Midazolam</b>	All PIs	↑ midazolam expected SQV/r ↑ midazolam (oral) AUC 1144% and C <sub>max</sub> 327%	<b>Do not coadminister oral midazolam and PIs.</b> Parenteral midazolam can be used with caution when given as a single dose in a monitored situation for procedural sedation.
<b>Suvorexant</b>	All PIs	↑ suvorexant expected	<b>Coadministration is not recommended.</b>
<b>Triazolam</b>	All PIs	↑ triazolam expected RTV (200 mg BID) ↑ triazolam half-life 1200% and AUC 2000%	<b>Do not coadminister.</b>
<b>Zolpidem</b>	PI/r or ATV/c or DRV/c	↑ zolpidem possible	Initiate zolpidem at a low dose. Dose reduction may be necessary.

**Table 19a. Drug Interactions between Protease Inhibitors and Other Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 14 of 14)**

Concomitant Drug	PI	Effect on PI and/or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>Miscellaneous Drugs</b>			
<b>Colchicine</b>	All PIs	RTV 100 mg BID ↑ colchicine AUC 296%, C <sub>max</sub> 184%  With all PIs with or without COBI or RTV: significant ↑ colchicine expected	<u>For Treatment of Gout Flares:</u> • Colchicine 0.6 mg x 1 dose, followed by 0.3 mg 1 hour later. Do not repeat dose for at least 3 days.  <u>With FPV without RTV:</u> • 1.2 mg x 1 dose and no repeat dose for at least 3 days  <u>For Prophylaxis of Gout Flares:</u> • Colchicine 0.3 mg once daily or every other day  <u>With FPV without RTV:</u> • Colchicine 0.3 mg BID or 0.6 mg once daily or 0.3 mg once daily  <u>For Treatment of Familial Mediterranean Fever:</u> • Do not exceed colchicine 0.6 mg once daily or 0.3 mg BID.  <u>With FPV without RTV:</u> • Do not exceed 1.2 mg once daily or 0.6 mg BID.  <b>Do not coadminister in patients with hepatic or renal impairment.</b>
<b>Salmeterol</b>	All PIs	↑ salmeterol possible	<b>Do not coadminister</b> because of potential increased risk of salmeterol-associated cardiovascular events.

<sup>a</sup> DHA is an active metabolite of artemether.

<sup>b</sup> The following products contain at least 35 mcg of ethinyl estradiol combined with norethindrone or norgestimate (generic formulation may also be available): Brevicon; Femcon Fe; Modicon; Norinyl 1/35; Ortho-Cyclen; Ortho-Novum 1/35, 7/7/7; Ortho Tri-Cyclen; Ovcon 35; Tri-Norinyl.

<sup>c</sup> The following products contain no more than 30 mcg of ethinyl estradiol combined with norethindrone or norgestimate (generic formulation may also be available): Lo Minastrin Fe; Lo Loestrin Fe; Loestrin 1/20, 1.5/30; Loestrin Fe 1/20, 1.5/30; Loestrin 24 Fe; Minastrin 24 Fe; Ortho Tri-Cyclen Lo.

<sup>d</sup> Norbuprenorphine is an active metabolite of buprenorphine.

<sup>e</sup> R-methadone is the active form of methadone.

**Key to Symbols:** ↑ = increase, ↓ = decrease, ↔ = no change

**Key to Acronyms:** 17-BMP = beclomethasone 17-monopropionate; APV = amprenavir; ART = antiretroviral therapy; ARV = antiretroviral; ATV = atazanavir; ATV/c = cobicistat-boosted atazanavir; ATV/r = ritonavir-boosted atazanavir; AUC = area under the curve; BID = twice daily; C<sub>max</sub> = maximum plasma concentration; C<sub>min</sub> = minimum plasma concentration; CNS = central nervous system; COBI = cobicistat; CrCl = creatinine clearance; CYP = cytochrome P; DHA = dihydroartemisinin; DRV = darunavir; DRV/c = cobicistat-boosted darunavir; DRV/r = ritonavir-boosted darunavir; ECG = electrocardiogram; FPV = fosamprenavir; FPV/r = ritonavir-boosted fosamprenavir; HCV = hepatitis C virus; INR = international normalized ratio; LPV = lopinavir; LPV/r = ritonavir-boosted lopinavir; PAH = pulmonary arterial hypertension; PI = protease inhibitor; PI/c = cobicistat-boosted protease inhibitor; PI/r = ritonavir-boosted protease inhibitor; PK = pharmacokinetic; PPI = proton pump inhibitor; QTc = QT corrected for heart rate; RTV = ritonavir; SQV = saquinavir; SQV/r = ritonavir-boosted saquinavir; TCA = tricyclic antidepressant; TDF = tenofovir disoproxil fumarate; TPV = tipranavir; TPV/r = ritonavir-boosted tipranavir; VPA = valproic acid

**Note:** FPV is a pro-drug of APV.

**Table 19b. Drug Interactions Between Non-Nucleoside Reverse Transcriptase Inhibitors and Other Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 1 of 7)**

This table provides information relating to PK interactions between NNRTIs and non-ARV drugs. For interactions between ARV agents and for dosing recommendations, refer to Tables [19c](#), [20a](#) and [20b](#).

**Note:** DLV is not included in this table. Please refer to the DLV FDA package insert for information regarding drug interactions.

Concomitant Drug Class/Name	NNRTI <sup>a</sup>	Effect on NNRTI and/or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>Acid Reducers</b>			
<b>Antacids</b>	RPV	↓ RPV expected when given simultaneously	Give antacids at least 2 hours before or at least 4 hours after RPV.
<b>H2 Receptor Antagonists</b>	RPV	↓ RPV	Give H2-receptor antagonists at least 12 hours before or at least 4 hours after RPV.
<b>PPIs</b>	RPV	With omeprazole 20 mg daily: • RPV AUC ↓ 40%, C <sub>min</sub> ↓ 33%	<b>Contraindicated. Do not coadminister.</b>
<b>Anticoagulants/Antiplatelets</b>			
<b>Warfarin</b>	EFV, NVP	↑ or ↓ warfarin possible	Monitor INR and adjust warfarin dose accordingly.
	ETR	↑ warfarin possible	Monitor INR and adjust warfarin dose accordingly.
<b>Clopidogrel</b>	ETR	↓ activation of clopidogrel possible	ETR may prevent metabolism of clopidogrel (inactive) to its active metabolite. Avoid coadministration, if possible.
<b>Anticonvulsants</b>			
<b>Carbamazepine Phenobarbital Phenytoin</b>	EFV	<u>Carbamazepine plus EFV:</u> • Carbamazepine AUC ↓ 27% • EFV AUC ↓ 36%  <u>Phenytoin plus EFV:</u> • ↓ EFV • ↓ phenytoin possible	Monitor anticonvulsant and EFV levels or, if possible, use alternative anticonvulsant to those listed.
	ETR	↓ anticonvulsant and ETR possible	<b>Do not coadminister.</b> Consider alternative anticonvulsant.
	NVP	↓ anticonvulsant and NVP possible	Monitor anticonvulsant and NVP levels and virologic responses or consider alternative anticonvulsant.
	RPV	↓ RPV possible	<b>Contraindicated. Do not coadminister.</b> Consider alternative anticonvulsant.
<b>Antidepressants</b>			
<b>Bupropion</b>	EFV	Bupropion AUC ↓ 55%	Titrate bupropion dose based on clinical response.
<b>Paroxetine</b>	EFV, ETR	No significant effect	No dosage adjustment necessary.
<b>Sertraline</b>	EFV	Sertraline AUC ↓ 39%	Titrate sertraline dose based on clinical response.



**Table 19b. Drug Interactions between Non-Nucleoside Reverse Transcriptase Inhibitors and Other Drugs** (Last updated April 8, 2015; last reviewed April 8, 2015) (page 2 of 7)

Concomitant Drug Class/Name	NNRTI <sup>a</sup>	Effect on NNRTI and/or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>Antifungals</b>			
<b>Fluconazole</b>	EFV	No significant effect	No dosage adjustment necessary.
	ETR	ETR AUC ↑ 86%	No dosage adjustment necessary. Use with caution.
	NVP	NVP AUC ↑ 110%	Increased risk of hepatotoxicity possible with this combination. Monitor NVP toxicity or use alternative ARV agent.
	RPV	↑ RPV possible	No dosage adjustment necessary. Clinically monitor for breakthrough fungal infection. (RPV 150 mg/day reduces ketoconazole exposure; no data on interaction with fluconazole.)
<b>Itraconazole</b>	EFV	Itraconazole and OH-itraconazole AUC, C <sub>max</sub> , and C <sub>min</sub> ↓ 35% to 44%	Failure to achieve therapeutic itraconazole concentrations has been reported. Avoid this combination if possible. If coadministered, closely monitor itraconazole concentration and adjust dose accordingly.
	ETR	↓ itraconazole possible ↑ ETR possible	Dose adjustments for itraconazole may be necessary. Monitor itraconazole level and antifungal response.
	NVP	↓ itraconazole possible ↑ NVP possible	Avoid combination if possible. If coadministered, monitor itraconazole concentration and adjust dose accordingly.
	RPV	↑ RPV possible	No dosage adjustment necessary. Clinically monitor for breakthrough fungal infection. (RPV 150 mg/day reduces ketoconazole exposure; no data on interaction with itraconazole.)
<b>Posaconazole</b>	EFV	Posaconazole AUC ↓ 50% ↔ EFV	Avoid concomitant use unless the benefit outweighs the risk. If coadministered, monitor posaconazole concentration and adjust dose accordingly.
	ETR	↑ ETR possible	No dosage adjustment necessary.
	RPV	↑ RPV possible	No dosage adjustment necessary. Clinically monitor for breakthrough fungal infection. (RPV 150 mg/day reduces ketoconazole exposure; no data on interaction with posaconazole.)
<b>Voriconazole</b>	EFV	Voriconazole AUC ↓ 77% EFV AUC ↑ 44%	<b>Contraindicated at standard doses.</b> <u>Dose adjustment:</u> • Voriconazole 400 mg BID, EFV 300 mg daily
	ETR	Voriconazole AUC ↑ 14% ETR AUC ↑ 36%	No dosage adjustment necessary; use with caution. Consider monitoring voriconazole level.
	NVP	↓ voriconazole possible ↑ NVP possible	Monitor for toxicity and antifungal response and/or voriconazole level.
	RPV	↑ RPV possible	No dosage adjustment necessary. Clinically monitor for breakthrough fungal infection. (RPV 150 mg/day reduces ketoconazole exposure; no data on interaction with voriconazole.)

**Table 19b. Drug Interactions between Non-Nucleoside Reverse Transcriptase Inhibitors and Other Drugs** (Last updated April 8, 2015; last reviewed April 8, 2015) (page 3 of 7)

Concomitant Drug Class/Name	NNRTI <sup>a</sup>	Effect on NNRTI and/or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>Antimalarials</b>			
<b>Artemether/ Lumefantrine</b>	EFV	Artemether AUC ↓ 79% DHA AUC ↓ 75% Lumefantrine AUC ↓ 56%	Clinical significance of the reduced antimalarial drug concentrations unknown. If used in combination with EFV, monitor closely for anti-malarial efficacy.
	ETR	Artemether AUC ↓ 38% DHA AUC ↓ 15% Lumefantrine AUC ↓ 13% ETR AUC ↑ 10%	Clinical significance of the reduced antimalarial drug concentrations unknown. If used in combination with ETR, monitor closely for anti-malarial efficacy.
	NVP	Artemether AUC ↓ 72% DHA AUC ↓ 37% <u>Lumefantrine:</u> • Study results are conflicting: lumefantrine AUC ↓ 25% in one study but ↑ 55.6% in another.	Clinical significance unknown. If used, monitor closely for anti-malarial efficacy and lumefantrine toxicity.
<b>Atovaquone/ Proguanil</b>	EFV	Atovaquone AUC ↓ 75% Proguanil AUC ↓ 43%	No dosage recommendation. Consider alternative drug for malaria prophylaxis, if possible.
<b>Antimycobacterials</b>			
<b>Bedaquiline</b>	EFV, NVP	↔ bedaquiline AUC	No dosage adjustment necessary.
<b>Clarithromycin</b>	EFV	Clarithromycin AUC ↓ 39%	Monitor for effectiveness or consider alternative agent, such as azithromycin, for MAC prophylaxis and treatment.
	ETR	Clarithromycin AUC ↓ 39% ETR AUC ↑ 42%	Consider alternative agent, such as azithromycin, for MAC prophylaxis and treatment.
	NVP	Clarithromycin AUC ↓ 31%	Monitor for effectiveness or use alternative agent, such as azithromycin, for MAC prophylaxis and treatment.
	RPV	↔ clarithromycin expected ↑ RPV possible	Consider alternative macrolide, such as azithromycin, for MAC prophylaxis and treatment.
<b>Rifabutin</b>	EFV	Rifabutin ↓ 38%	<u>Dose:</u> • Rifabutin 450–600 mg/day; or • Rifabutin 600 mg 3 times/week <b>if</b> EFV is not coadministered with a PI.
	ETR	Rifabutin and metabolite AUC ↓ 17% ETR AUC ↓ 37%	<b>If ETR is used with an RTV-boosted PI, rifabutin should not be coadministered.</b> <u>Dose:</u> • Rifabutin 300 mg once daily <b>if</b> ETR is not coadministered with an RTV-boosted PI.
	NVP	Rifabutin AUC ↑ 17% and metabolite AUC ↑ 24% NVP C <sub>min</sub> ↓ 16%	No dosage adjustment necessary. Use with caution.
	RPV	RPV AUC ↓ 46%	Increase RPV to 50 mg once daily.

**Table 19b. Drug Interactions between Non-Nucleoside Reverse Transcriptase Inhibitors and Other Drugs** (Last updated April 8, 2015; last reviewed April 8, 2015) (page 4 of 7)

Concomitant Drug Class/Name	NNRTI <sup>a</sup>	Effect on NNRTI and/or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
Antimycobacterials, continued			
Rifampin	EFV	EFV AUC ↓ 26%	Maintain EFV dose at 600 mg once daily and monitor for virologic response. Consider therapeutic drug monitoring.  Some clinicians suggest EFV 800 mg dose in patients who weigh more than 60 kg.
	ETR	Significant ↓ ETR possible	Do not coadminister.
	NVP	NVP ↓ 20% to 58%	Do not coadminister.
	RPV	RPV AUC ↓ 80%	Contraindicated. Do not coadminister.
Rifapentine	EFV, ETR, NVP, RPV	↓ NNRTI expected	Do not coadminister.
Benzodiazepines			
Alprazolam	EFV, ETR, NVP, RPV	No data	Monitor for therapeutic effectiveness of alprazolam.
Diazepam	ETR	↑ diazepam possible	Decreased dose of diazepam may be necessary.
Lorazepam	EFV	Lorazepam C <sub>max</sub> ↑ 16%, AUC ↔	No dosage adjustment necessary.
Midazolam	EFV	Significant ↑ midazolam expected	Do not coadminister with oral midazolam.  Parenteral midazolam can be used with caution as a single dose and can be given in a monitored situation for procedural sedation.
Triazolam	EFV	Significant ↑ triazolam expected	Do not coadminister.
Cardiac Medications			
Dihydropyridine CCBs	EFV, NVP	↓ CCBs possible	Titrate CCB dose based on clinical response.
Diltiazem Verapamil	EFV	Diltiazem AUC ↓ 69% ↓ verapamil possible	Titrate diltiazem or verapamil dose based on clinical response.
	NVP	↓ diltiazem or verapamil possible	
Corticosteroids			
Dexamethasone	EFV, ETR, NVP	↓ EFV, ETR, NVP possible	Consider alternative corticosteroid for long-term use. If dexamethasone is used with NNRTI, monitor virologic response.
	RPV	Significant ↓ RPV possible	Contraindicated with more than a single dose of dexamethasone.
Hepatitis C Direct-Acting Antiviral Agents			
Boceprevir	EFV	EFV AUC ↑ 20% Boceprevir AUC ↓ 19%, C <sub>min</sub> ↓ 44%	Coadministration is not recommended.
	ETR	ETR AUC ↓ 23% Boceprevir AUC, C <sub>max</sub> ↑ 10%	No dosage adjustment necessary.

**Table 19b. Drug Interactions between Non-Nucleoside Reverse Transcriptase Inhibitors and Other Drugs** (Last updated April 8, 2015; last reviewed April 8, 2015) (page 5 of 7)

Concomitant Drug Class/Name	NNRTI <sup>a</sup>	Effect on NNRTI and/or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>Hepatitis C Direct-Acting Antiviral Agents, continued</b>			
<b>Dasabuvir plus Parataprevir/ Ombitasivir/RTV</b>	EFV	No data	<b>Contraindicated. Do not coadminister.</b>
	ETR, NVP	↓ DAAs possible	<b>Do not coadminister.</b>
	RPV	RPV AUC ↑ 150% to 225%	<b>Do not coadminister because of potential for QT interval prolongation with higher concentrations of RPV.</b>
<b>Ledipasvir/ Sofosbuvir</b>	EFV	Ledipasvir AUC, C <sub>min</sub> , C <sub>max</sub> – all ↓ 34% Sofosbuvir: no significant effect	No dosage adjustment necessary.
	ETR, NVP, RPV	No significant effect expected	
<b>Simeprevir</b>	EFV	Simeprevir AUC ↓ 71%, C <sub>min</sub> ↓ 91% ↔ EFV	<b>Coadministration is not recommended.</b>
	ETR, NVP	↓ simeprevir expected	<b>Coadministration is not recommended.</b>
	RPV	↔ simeprevir and RPV	No dosage adjustment necessary.
<b>Herbal Products</b>			
<b>St. John's Wort</b>	EFV, ETR, NVP, RPV	↓ NNRTI	<b>Do not coadminister.</b>
<b>Hormonal Contraceptives</b>			
<b>Hormonal Contraceptives</b>	EFV	Ethinyl estradiol ↔ Levonorgestrel AUC ↓ 83% Norelgestromin AUC ↓ 64% Etonogestrel (implant) AUC ↓ 63%	Use alternative or additional contraceptive methods. Norelgestromin and levonorgestrel are active metabolites of norgestimate.
	ETR	Ethinyl estradiol AUC ↑ 22% Norethindrone: no significant effect	No dosage adjustment necessary.
	NVP	Ethinyl estradiol AUC ↓ 20% Norethindrone AUC ↓ 19%	Use alternative or additional contraceptive methods.
		DMPA: no significant change	No dosage adjustment necessary.
	RPV	Ethinyl estradiol AUC ↑ 14% Norethindrone: no significant change	No dosage adjustment necessary.
<b>Levonorgestrel</b> For emergency contraception	EFV	Levonorgestrel AUC ↓ 58%	Effectiveness of emergency post-coital contraception may be diminished.

**Table 19b. Drug Interactions between Non-Nucleoside Reverse Transcriptase Inhibitors and Other Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 6 of 7)**

Concomitant Drug Class/Name	NNRTI <sup>a</sup>	Effect on NNRTI and/or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>HMG-CoA Reductase Inhibitors</b>			
<b>Atorvastatin</b>	EFV, ETR	Atorvastatin AUC ↓ 32% to 43%	Adjust atorvastatin according to lipid responses, not to exceed the maximum recommended dose.
	RPV	Atorvastatin AUC ↔ Atorvastatin metabolites ↑	No dosage adjustment necessary.
<b>Fluvastatin</b>	ETR	↑ fluvastatin possible	Dose adjustments for fluvastatin may be necessary.
<b>Lovastatin Simvastatin</b>	EFV	Simvastatin AUC ↓ 68%	Adjust simvastatin dose according to lipid responses, not to exceed the maximum recommended dose. If EFV is used with a RTV-boosted PI, simvastatin and lovastatin should be avoided.
	ETR, NVP	↓ lovastatin possible ↓ simvastatin possible	Adjust lovastatin or simvastatin dose according to lipid responses, not to exceed the maximum recommended dose. If ETR or NVP is used with a RTV-boosted PI, simvastatin and lovastatin should be avoided.
<b>Pitavastatin</b>	EFV	Pitavastatin AUC ↓ 11%, C <sub>max</sub> ↑ 20%	No dosage adjustment necessary.
	ETR, NVP, RPV	No data	No significant effect expected. No dosage adjustment necessary.
<b>Pravastatin Rosuvastatin</b>	EFV	Pravastatin AUC ↓ 44% Rosuvastatin: no data	Adjust statin dose according to lipid responses, not to exceed the maximum recommended dose.
	ETR	No significant effect expected	No dosage adjustment necessary.
<b>Immunosuppressants</b>			
<b>Cyclosporine Sirolimus Tacrolimus</b>	EFV, ETR, NVP	↓ immunosuppressant possible	Increase in immunosuppressant dose may be necessary. Therapeutic drug monitoring of immunosuppressant is recommended. Consult with specialist as necessary.
<b>Narcotics/Treatments for Opioid Dependence</b>			
<b>Buprenorphine</b>	EFV	Buprenorphine AUC ↓ 50% Norbuprenorphine <sup>b</sup> AUC ↓ 71%	No dosage adjustment recommended; monitor for withdrawal symptoms.
	ETR	Buprenorphine AUC ↓ 25%	No dosage adjustment necessary.
	NVP	No significant effect	No dosage adjustment necessary.
<b>Methadone</b>	EFV	Methadone AUC ↓ 52%	Opioid withdrawal common; increased methadone dose often necessary.
	ETR	No significant effect	No dosage adjustment necessary.
	NVP	Methadone AUC ↓ 37% to 51% NVP: no significant effect	Opioid withdrawal common; increased methadone dose often necessary.
	RPV	R-methadone <sup>c</sup> AUC ↓ 16%	No dosage adjustment necessary, but monitor for withdrawal symptoms.



**Table 19b. Drug Interactions between Non-Nucleoside Reverse Transcriptase Inhibitors and Other Drugs** (Last updated April 8, 2015; last reviewed April 8, 2015) (page 7 of 7)

Concomitant Drug Class/Name	NNRTI <sup>a</sup>	Effect on NNRTI and/or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>PDE5 Inhibitors</b>			
<b>Avanafil</b>	EFV, ETR, NVP, RPV	No data	<b>Coadministration is not recommended.</b>
<b>Sildenafil</b>	ETR	Sildenafil AUC ↓ 57%	May need to increase sildenafil dose based on clinical effect.
	RPV	↔ sildenafil	No dosage adjustment necessary.
<b>Tadalafil</b>	ETR	↓ tadalafil possible	May need to increase tadalafil dose based on clinical effect.
<b>Vardenafil</b>	ETR	↓ vardenafil possible	May need to increase vardenafil dose based on clinical effect.

<sup>a</sup> Approved dose for RPV is 25 mg once daily. Most PK interaction studies were performed using 75 to 150 mg per dose.

<sup>b</sup> Norbuprenorphine is an active metabolite of buprenorphine.

<sup>c</sup> R-methadone is the active form of methadone.

**Key to Symbols:** ↑ = increase, ↓ = decrease, ↔ = no change

**Key to Acronyms:** ARV = antiretroviral; AUC = area under the curve; BID = twice daily; CCB = calcium channel blockers; C<sub>max</sub> = maximum plasma concentration; C<sub>min</sub> = minimum plasma concentration; DAAs = direct-acting antivirals; DHA = dihydroartemisinin; DLV = delavirdine; DMPA = depot medroxyprogesterone acetate; EFV = efavirenz; ETR = etravirine; FDA = Food and Drug Administration; HMG-CoA = hydroxy-methylglutaryl-coenzyme A; INR = international normalized ratio; MAC = *Mycobacterium avium* complex; NNRTI = non-nucleoside reverse transcriptase inhibitor; NVP = nevirapine; OH-itraconazole = active metabolite of itraconazole; PDE5 = phosphodiesterase type 5; PI = protease inhibitor; PK = pharmacokinetic; PPI = proton pump inhibitor; RPV = rilpivirine; RTV = ritonavir

**Table 19c. Drug Interactions Between Nucleoside Reverse Transcriptase Inhibitors and Other Drugs (Including Antiretroviral Agents) (Last updated April 8, 2015; last reviewed April 8, 2015) (page 1 of 2)**

Concomitant Drug Class/Name	NRTI	Effect on NRTI and/or Concomitant Drug Concentrations	Dosage Recommendations and Clinical Comments
<b>Non-ARV Antivirals</b>			
<b>Adefovir</b>	TDF	No data	<b>Do not coadminister.</b> Serum concentrations of TDF and/or other renally eliminated drugs may be increased.
<b>Ganciclovir</b> <b>Valganciclovir</b>	TDF	No data	Serum concentrations of these drugs and/or TDF may be increased. Monitor for dose-related toxicities.
	ZDV	No significant effect	Potential increase in hematologic toxicities
<b>Ledipasvir/Sofosbuvir</b>	TDF	<ul style="list-style-type: none"> <li>Ledipasvir ↑ TDF AUC 40% to 98% when TDF given with RPV and EFV</li> <li>Further ↑ TDF possible if TDF given with PIs</li> </ul>	<p>No dose adjustment necessary. Monitor for TDF toxicity.</p> <p>The safety of increased TDF exposure when ledipasvir/sofosbuvir is coadministered with TDF and a PI/r, ATV/c, or DRV/c has not been established. Consider alternative HCV or ARV drugs to avoid increased TDF toxicities. If coadministration is necessary, monitor for TDF-associated adverse reactions.</p> <p>Coadministration of ledipasvir/sofosbuvir with EVG/c/TDF/FTC <b>is not recommended.</b></p>
<b>Ribavirin</b>	ddl	↑ intracellular ddl	<b>Contraindicated. Do not coadminister.</b> Fatal hepatic failure and other ddl-related toxicities have been reported with coadministration.
	ZDV	Ribavirin inhibits phosphorylation of ZDV.	Avoid coadministration if possible, or closely monitor HIV virologic response and possible hematologic toxicities.
<b>INSTIs</b>			
<b>DTG</b>	TDF	<ul style="list-style-type: none"> <li>TDF AUC ↑ 12% and C<sub>min</sub> ↑ 19%</li> <li>DTG ↔</li> </ul>	No dosage adjustment necessary.
<b>RAL</b>	TDF	RAL AUC ↑ 49%	No dosage adjustment necessary.
<b>Narcotics/Treatment for Opioid Dependence</b>			
<b>Buprenorphine</b>	3TC, ddl, TDF, ZDV	No significant effect	No dosage adjustment necessary.
<b>Methadone</b>	ABC	Methadone clearance ↑ 22%	No dosage adjustment necessary.
	d4T	d4T AUC ↓ 23%	No dosage adjustment necessary.
	ZDV	ZDV AUC ↑ 29% to 43%	Monitor for ZDV-related adverse effects.
<b>NRTIs</b>			
<b>ddl</b>	d4T	No significant PK interaction	<b>Do not coadminister.</b> Additive toxicities of peripheral neuropathy, lactic acidosis, and pancreatitis seen with this combination.
	TDF	ddl-EC AUC and C <sub>max</sub> ↑ 48% to 60%	<b>Avoid coadministration.</b>

**Table 19c. Drug Interactions Between Nucleoside Reverse Transcriptase Inhibitors and Other Drugs (Including Antiretroviral Agents) (Last updated April 8, 2015; last reviewed April 8, 2015) (page 2 of 2)**

Concomitant Drug Class/Name	NRTI	Effect on NRTI and/or Concomitant Drug Concentrations	Dosage Recommendations and Clinical Comments
<b>Other</b>			
Allopurinol	ddl	ddl AUC ↑ 113% <u>In patients with renal impairment:</u> • ddl AUC ↑ 312%	<b>Contraindicated.</b> Potential for increased ddl-associated toxicities.
Atovaquone	ZDV	ZDV AUC ↑ 31%	Monitor for ZDV-related adverse effects.
<b>PIs</b>			
<b>ATV +/- RTV or COBI</b>	ddl	<u>With ddl-EC plus ATV (with food):</u> • ddl AUC ↓ 34% • ATV no change	Administer ATV with food 2 hours before or 1 hour after ddl.
	TDF	<u>With ATV (unboosted):</u> • ATV AUC ↓ 25% and C <sub>min</sub> ↓ 23% to 40% (higher C <sub>min</sub> with RTV than without RTV) • TDF AUC ↑ 24% to 37%	<b>Avoid concomitant use without RTV or COBI.</b> <u>Dose:</u> • ATV 300 mg daily plus (RTV 100 mg or COBI 150 mg) daily when coadministered with TDF 300 mg daily. • If using TDF and H2 receptor antagonist in ART-experienced patients, use ATV 400 mg daily plus (RTV 100 mg or COBI 150 mg) daily.  Monitor for TDF-associated toxicity.
	ZDV	<u>With ATV (unboosted):</u> • ZDV C <sub>min</sub> ↓ 30% and AUC ↔	Clinical significance unknown.
<b>DRV/c</b>	TDF	Increased TDF possible	Monitor for TDF-associated toxicity.
<b>DRV/r</b>	TDF	TDF AUC ↑ 22% and C <sub>min</sub> ↑ 37%	Clinical significance unknown. Monitor for TDF toxicity.
<b>LPV/r</b>	TDF	• LPV/r AUC ↓ 15% • TDF AUC ↑ 34%	Clinical significance unknown. Monitor for TDF toxicity.
<b>TPV/r</b>	ABC	ABC AUC ↓ 35% to 44%	Appropriate doses for this combination have not been established.
	ddl	• ddl-EC AUC ↔ and C <sub>min</sub> ↓ 34% • TPV/r ↔	Separate doses by at least 2 hours.
	TDF	• TDF AUC ↔ • TPV/r AUC ↓ 9% to 18% and C <sub>min</sub> ↓ 12% to 21%	No dosage adjustment necessary.
	ZDV	• ZDV AUC ↓ 35% • TPV/r AUC ↓ 31% to 43%	Appropriate doses for this combination have not been established.

**Key to Symbols:** ↑ = increase, ↓ = decrease, ↔ = no change

**Key to Abbreviations:** 3TC = lamivudine; ABC = abacavir; ART = antiretroviral therapy; ARV = antiretroviral; ATV = atazanavir; ATV/c = atazanavir/cobicistat; AUC = area under the curve; C<sub>max</sub> = maximum plasma concentration; C<sub>min</sub> = minimum plasma concentration; COBI = cobicistat; d4T = stavudine; ddl = didanosine; DRV/c = darunavir/cobicistat; DRV/r = darunavir/ritonavir; DTG = dolutegravir; EC = enteric coated; EFV = efavirenz; EFV/c/TDF/FTC = efavirenz/cobicistat/tenofovir disoproxil fumarate/emtricitabine; HCV = hepatitis C virus; INSTI = integrase strand transfer inhibitor; LPV/r = lopinavir/ritonavir; NRTI = nucleoside reverse transcriptase inhibitor; PI = protease inhibitor; PI/r = ritonavir-boosted protease inhibitor; PK = pharmacokinetic; RAL = raltegravir; RPV = rilpivirine; RTV = ritonavir; TDF = tenofovir disoproxil fumarate; TPV/r = tipranavir/ritonavir; ZDV = zidovudine

**Table 19d. Drug Interactions Between Integrase Strand Transfer Inhibitors and Other Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 1 of 11)**

This table provides information on known or predicted PK interactions between INSTIs and non-ARV drugs. The table includes information on interactions with EVG, an INSTI that is available in two formulations:

1. A fixed-dose combination tablet of EVG/c/TDF/FTC indicated for use as a single-tablet regimen
2. A stand-alone tablet indicated for use with a RTV-boosted PI (PI/r) and other ARVs in ARV treatment-experienced patients.

In the table, the drug interactions with EVG/c/TDF/FTC and those with EVG plus (PI/r) are presented separately. For several interactions, no dose adjustment is necessary for EVG when given with a concomitant drug; however, since EVG should always be given with a PI/r, clinicians should refer to [Table 19a](#) for recommendations on the management of drug interactions resulting from the PI/r used with EVG.

Concomitant Drug Class/Name	INSTI	Effect on INSTI or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>Acid Reducers</b>			
<b>Aluminium, Magnesium +/- Calcium Containing Antacids</b> Please refer to the Miscellaneous Drugs section of this table for recommendations on use with other polyvalent cation products (e.g., iron, calcium supplements, multivitamins).	DTG	DTG AUC ↓ 74% if given simultaneously with antacid; DTG AUC ↓ 26% if given 2 hours before antacid	Give DTG at least 2 hours before or at least 6 hours after antacids containing polyvalent cations.
	EVG/c/TDF/FTC	EVG AUC ↓ 40% to 50% if given simultaneously with antacid; EVG AUC ↓ 15% to 20% if given 2 hours before or after antacid; ↔ with 4-hour interval	Separate EVG/c/TDF/FTC and antacid administration by more than 2 hours.
	EVG plus (PI/r)	• EVG AUC ↓ 40% to 50% if given simultaneously with antacid; • EVG AUC ↓ 15% to 20% if antacid given 2 hours before or after EVG; ↔ with 4-hour interval	Separate EVG and antacid administration by more than 2 hours.
	RAL	<u>Al-Mg Hydroxide Antacid:</u> • RAL C <sub>min</sub> ↓ 54% to 63% <u>CaCO<sub>3</sub> Antacid:</u> • RAL C <sub>min</sub> ↓ 32%	<b>Do not coadminister RAL and Al-Mg hydroxide antacids.</b> Use alternative acid reducing agent.  No dosing separation necessary when coadministering RAL and CaCO <sub>3</sub> antacids.
<b>H2-Receptor Antagonists</b>	EVG/c/TDF/FTC	No significant effect	No dosage adjustment necessary.
	EVG plus (PI/r)	↔ EVG	No dosage adjustment necessary for EVG. Refer to <a href="#">Table 19a</a> for information on PI/r interactions.
<b>PPIs</b>	DTG	No significant effect	No dosage adjustment necessary.
	EVG/c/TDF/FTC	No significant effect	No dosage adjustment necessary.
	EVG plus (PI/r)	↔ EVG	No dosage adjustment necessary for EVG. Refer to <a href="#">Table 19a</a> for information on PI/r interactions.
	RAL	RAL AUC ↑ 212% and C <sub>min</sub> ↑ 46%	No dosage adjustment necessary.

**Table 19d. Drug Interactions Between Integrase Strand Transfer Inhibitors and Other Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 2 of 11)**

Concomitant Drug Class/Name	INSTI	Effect on INSTI or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>Anticoagulants and Antiplatelets</b>			
<b>Apixaban</b>	• EVG/c/TDF/FTC • EVG plus (PI/r)	↑ apixaban expected	<b>Avoid concomitant use.</b>
<b>Dabigatran</b>	• EVG/c/TDF/FTC • EVG plus (PI/r)	↑ dabigatran possible	No dosage adjustment for dabigatran if CrCl >50 mL/min. <b>Avoid coadministration if CrCl &lt;50 mL/min.</b>
<b>Rivaroxaban</b>	• EVG/c/TDF/FTC • EVG plus (PI/r)	↑ rivaroxaban expected	<b>Avoid concomitant use.</b>
<b>Ticagrelor</b>	• EVG/c/TDF/FTC • EVG plus (PI/r)	↑ ticagrelor expected	<b>Avoid concomitant use.</b>
<b>Vorapaxar</b>	• EVG/c/TDF/FTC • EVG plus (PI/r)	↑ vorapaxar expected	<b>Avoid concomitant use.</b>
<b>Warfarin</b>	• EVG/c/TDF/FTC • EVG plus (PI/r)	No data, but warfarin levels may be affected	Monitor INR and adjust warfarin dose accordingly.
<b>Anticonvulsants</b>			
<b>Carbamazepine Oxcarbazepine Phenobarbital Phenytoin</b>	DTG	↓ DTG possible	Consider alternative anticonvulsant.
	EVG/c/TDF/FTC	• ↑ carbamazepine possible • ↓ EVG possible • ↓ COBI possible	Consider alternative anticonvulsant.
	EVG plus (PI/r)	↓ EVG	Consider alternative anticonvulsant.
<b>Ethosuximide</b>	• EVG/c/TDF/FTC • EVG plus (PI/r)	↑ ethosuximide possible	Clinically monitor for ethosuximide toxicities.
<b>Antidepressants/Anxiolytics/Antipsychotics</b> Also see Sedative/Hypnotics section below.			
<b>Bupropion</b>	EVG/c/TDF/FTC	↑ or ↓ bupropion possible	Titrate bupropion dose based on clinical response.
	EVG plus (PI/r)	↓ bupropion possible	Titrate bupropion dose based on clinical response.
<b>Buspirone</b>	• EVG/c/TDF/FTC • EVG plus (PI/r)	↑ buspirone possible	Initiate buspirone at a low dose. Dose reduction may be necessary.
<b>Fluvoxamine</b>	• EVG/c/TDF/FTC • EVG plus (PI/r)	↑ or ↓ EVG possible	Consider alternative antidepressant or ARV.



**Table 19d. Drug Interactions Between Integrase Strand Transfer Inhibitors and Other Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 3 of 11)**

Concomitant Drug Class/Name	INSTI	Effect on INSTI or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>Antidepressants/Anxiolytics/Antipsychotics, continued</b> Also see Sedative/Hypnotics section below.			
<b>Quetiapine</b>	<ul style="list-style-type: none"> <li>• EVG/c/TDF/FTC</li> <li>• EVG plus (PI/r)</li> </ul>	↑ quetiapine AUC expected.	<p><u>Initiation of quetiapine in a patient receiving EVG/c/TDF/FTC:</u></p> <ul style="list-style-type: none"> <li>• Start quetiapine at the lowest dose and titrate up as needed. Monitor for quetiapine efficacy and adverse effects.</li> </ul> <p><u>Initiation of EVG/c/TDF/FTC in a patient receiving a stable dose of quetiapine:</u></p> <ul style="list-style-type: none"> <li>• Reduce quetiapine dose to 1/6 of the original dose, and closely monitor for quetiapine efficacy and adverse effects.</li> </ul>
<b>SSRIs</b> Citalopram Escitalopram Fluoxetine Paroxetine Sertraline	EVG/c/TDF/FTC	↑ SSRI possible	Initiate with lowest dose of SSRI and titrate dose carefully based on antidepressant response.
	EVG plus (PI/r)	↑ or ↓ SSRI possible	Titrate SSRI dose based on clinical response.
<b>TCAs</b> Amitriptyline Desipramine Doxepin Imipramine Nortriptyline	EVG/c/TDF/FTC	Desipramine AUC ↑ 65%	Initiate with lowest dose of TCA and titrate dose carefully.
	EVG plus (PI/r)	↑ TCA expected	Initiate with lowest dose of TCA and titrate dose carefully based on antidepressant response and/or drug levels.
<b>Trazodone</b>	<ul style="list-style-type: none"> <li>• EVG/c/TDF/FTC</li> <li>• EVG plus (PI/r)</li> </ul>	↑ trazodone possible	Initiate with lowest dose of trazodone and titrate dose carefully.
<b>Antifungals</b>			
<b>Itraconazole</b>	EVG/c/TDF/FTC	<ul style="list-style-type: none"> <li>• ↑ itraconazole expected</li> <li>• ↑ EVG and COBI possible</li> </ul>	Consider monitoring itraconazole level to guide dosage adjustments. High itraconazole doses (>200 mg/day) are not recommended unless dose is guided by itraconazole levels.
	EVG plus (PI/r)	↑ EVG possible	Refer to <a href="#">Table 19a</a> for PI recommendations.
<b>Posaconazole</b>	EVG/c/TDF/FTC	<ul style="list-style-type: none"> <li>• ↑ EVG and COBI possible</li> <li>• ↑ posaconazole possible</li> </ul>	If coadministered, monitor posaconazole concentrations.
	EVG plus (PI/r)	↑ EVG possible	Refer to <a href="#">Table 19a</a> for PI recommendations.

**Table 19d. Drug Interactions Between Integrase Strand Transfer Inhibitors and Other Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 4 of 11)**

Concomitant Drug Class/Name	INSTI	Effect on INSTI or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>Antifungals, continued</b>			
<b>Voriconazole</b>	EVG/c/TDF/FTC	<ul style="list-style-type: none"> <li>• ↑ voriconazole expected</li> <li>• ↑ EVG and COBI possible</li> </ul>	Risk/benefit ratio should be assessed to justify use of voriconazole. If administered, consider monitoring voriconazole level. Adjust dose accordingly.
	EVG plus (PI/r)	Changes in voriconazole and EVG possible	Refer to <a href="#">Table 19a</a> for PI recommendations.
<b>Antimycobacterials</b>			
<b>Clarithromycin</b>	EVG/c/TDF/FTC	<ul style="list-style-type: none"> <li>• ↑ clarithromycin possible</li> <li>• ↑ COBI possible</li> </ul>	<p>CrCl 50–60 mL/min:</p> <ul style="list-style-type: none"> <li>• Reduce clarithromycin dose by 50%.</li> </ul> <p>CrCl &lt;50 mL/min:</p> <ul style="list-style-type: none"> <li>• EVG/c/TDF/FTC is not recommended.</li> </ul>
<b>Rifabutin</b>	DTG	<p><u>Rifabutin (300 mg once daily):</u></p> <ul style="list-style-type: none"> <li>• DTG AUC ↔ and C<sub>min</sub> ↓ 30%</li> </ul>	No dosage adjustment necessary.
	EVG/c/TDF/FTC	<p><u>Rifabutin 150 mg every other day with EVG/c/TDF/FTC once daily compared to Rifabutin 300 mg once daily alone:</u></p> <ul style="list-style-type: none"> <li>• No significant change in rifabutin AUC</li> <li>• 25-O-desacetyl-rifabutin AUC ↑ 625%</li> <li>• EVG AUC ↓ 21% and C<sub>min</sub> ↓ 67%</li> </ul>	<b>Do not coadminister.</b>
	EVG plus (PI/r)	<ul style="list-style-type: none"> <li>• ↔ EVG</li> <li>• ↔ rifabutin AUC</li> <li>• 25-O-desacetyl-rifabutin AUC ↑ 951%</li> </ul>	Refer to <a href="#">Table 19a</a> for dosing recommendations for rifabutin with PI.
	RAL	RAL AUC ↑ 19% and C <sub>min</sub> ↓ 20%	No dosage adjustment necessary.

**Table 19d. Drug Interactions Between Integrase Strand Transfer Inhibitors and Other Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 5 of 11)**

Concomitant Drug Class/Name	INSTI	Effect on INSTI or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>Antimycobacterials, continued</b>			
<b>Rifampin</b>	DTG	<u>Rifampin with DTG 50 mg BID compared to DTG 50 mg BID alone:</u> • DTG AUC ↓ 54% and C <sub>min</sub> ↓ 72%  <u>Rifampin with DTG 50 mg BID compared to DTG 50 mg once daily alone:</u> • DTG AUC ↑ 33% and C <sub>min</sub> ↑ 22%	<u>Dose:</u> • DTG 50 mg BID (instead of 50 mg once daily) for patients without suspected or documented INSTI mutation.  <b>Alternative to rifampin should be used in patients with certain suspected or documented INSTI-associated resistance substitutions. Consider using rifabutin.</b>
	• EVG/c/TDF/FTC • EVG plus (PI/r)	Significant ↓ EVG and COBI expected	<b>Do not coadminister.</b>
	RAL	<u>RAL 400 mg:</u> • RAL AUC ↓ 40% and C <sub>min</sub> ↓ 61%  <u>Compared with RAL 400 mg BID alone, Rifampin with RAL 800 mg BID:</u> • RAL AUC ↑ 27% and C <sub>min</sub> ↓ 53%	<u>Dose:</u> • RAL 800 mg BID  Monitor closely for virologic response or consider using rifabutin as an alternative rifamycin.
<b>Rifapentine</b>	DTG	Significant ↓ DTG expected	<b>Do not coadminister.</b>
	• EVG/c/TDF/FTC • EVG plus (PI/r)	Significant ↓ EVG and COBI expected	<b>Do not coadminister.</b>
	RAL	RAL C <sub>min</sub> ↓ 41%	<b>Do not coadminister.</b>
<b>Cardiac Medications</b>			
<b>Anti-Arrhythmics</b>  Amiodarone Bepridil Digoxin Disopyramide Dronedarone Flecainide Systemic lidocaine Mexilitine Propafenone Quinidine	EVG/c/TDF/FTC	• ↑ anti-arrhythmics possible  • digoxin C <sub>max</sub> ↑ 41% and AUC no significant change	Use anti-arrhythmics with caution. Therapeutic drug monitoring, if available, is recommended for anti-arrhythmics.
	EVG plus (PI/r)	↑ anti-arrhythmics possible	Refer to <a href="#">Table 18</a> and <a href="#">19a</a> for use of anti-arrhythmics and PI/r

**Table 19d. Drug Interactions Between Integrase Strand Transfer Inhibitors and Other Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 6 of 11)**

Concomitant Drug Class/Name	INSTI	Effect on INSTI or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>Cardiac Medications, continued</b>			
<b>Bosentan</b>	EVG/c/TDF/FTC	↑ bosentan possible	<p><u>In patients on EVG/c/TDF/FTC ≥10 days:</u></p> <ul style="list-style-type: none"> <li>• Start bosentan at 62.5 mg once daily or every other day based on individual tolerability.</li> </ul> <p><u>In patients on bosentan who require EVG/c/TDF/FTC:</u></p> <ul style="list-style-type: none"> <li>• Stop bosentan ≥36 hours before EVG/c/TDF/FTC initiation. At least 10 days after initiation of EVG/c/TDF/FTC, resume bosentan at 62.5 mg once daily or every other day based on individual tolerability.</li> </ul>
	EVG plus (PI/r)	↑ bosentan possible	Refer to <a href="#">Table 19a</a> for recommendations on bosentan dosing when used with PI/r.
<b>Beta-blockers</b> (e.g., metoprolol, timolol)	<ul style="list-style-type: none"> <li>• EVG/c/TDF/FTC</li> <li>• EVG plus (PI/r)</li> </ul>	↑ beta-blockers possible	<p>Beta-blocker dose may need to be decreased; adjust dose based on clinical response.</p> <p>Consider using beta-blockers that are not metabolized by CYP450 enzymes (e.g., atenolol, labetalol, nadolol, sotalol).</p>
<b>Dofetilide</b>	DTG	↑ dofetilide expected	<b>Do not coadminister.</b>
<b>CCBs</b>	<ul style="list-style-type: none"> <li>• EVG/c/TDF/FTC</li> <li>• EVG plus (PI/r)</li> </ul>	↑ CCBs possible	<p>Coadminister with caution. Titrate CCB dose and monitor for CCB efficacy and toxicities.</p> <p>Refer to <a href="#">Table 19a</a> for diltiazem plus ATV/r and SQV/r recommendations.</p>
<b>Corticosteroids</b>			
<b>Dexamethasone</b> (systemic)	EVG/c/TDF/FTC	↓ EVG and COBI possible	Use systemic dexamethasone with caution. Monitor virologic response to ART. Consider alternative corticosteroid.
	EVG plus (PI/r)	↓ EVG possible	
<b>Fluticasone</b> Inhaled/Intranasal	<ul style="list-style-type: none"> <li>• EVG/c/TDF/FTC</li> <li>• EVG plus (PI/r)</li> </ul>	↑ fluticasone possible	Coadministration may result in adrenal insufficiency and Cushing's syndrome. Consider alternative therapy (e.g., beclomethasone), particularly for long-term use.
<b>Methylprednisolone, Prednisolone, Triamcinolone</b> Local injections, including intra-articular, epidural, intra-orbital	<ul style="list-style-type: none"> <li>• EVG/c/TDF/FTC</li> <li>• EVG plus (PI/r)</li> </ul>	↑ glucocorticoids expected	Coadministration may result in adrenal insufficiency and Cushing's syndrome. <b>Do not coadminister.</b>

**Table 19d. Drug Interactions Between Integrase Strand Transfer Inhibitors and Other Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 7 of 11)**

Concomitant Drug Class/Name	INSTI	Effect on INSTI or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>Hepatitis C Direct Acting Antivirals</b>			
<b>Boceprevir</b>	DTG	DTG AUC ↔	No dosage adjustment necessary.
	EVG/c/TDF/FTC	No data	<b>Do not coadminister.</b>
	EVG plus (PI/r)	↓ boceprevir	<b>Do not coadminister.</b>
	RAL	No significant effect	No dosage adjustment necessary.
<b>Dasabuvir plus Ombitasvir/Paritaprevir/r</b>	RAL	RAL AUC ↑ 134%	No dosage adjustment necessary.
	DTG	No data	<b>No dosing recommendations at this time.</b>
	• EVG plus (PI/r) • EVG/c/TDF/FTC	No data	<b>Do not coadminister.</b>
<b>Ledipasvir/Sofosbuvir</b>	EVG/c/TDF/FTC	↑ TDF and ↑ ledipasvir expected	<b>Do not coadminister.</b>
	EVG plus (PI/r)	↔ EVG expected	Refer to <a href="#">Table 19a</a> for PI dosing recommendations.
<b>Simeprevir</b>	EVG/c/TDF/FTC	↑ simeprevir expected	<b>Coadministration is not recommended.</b>
	EVG plus (PI/r)	↔ EVG expected	<b>Coadministration is not recommended.</b>
	RAL	No significant effect	No dosage adjustment necessary.
<b>Sofosbuvir</b>	All INSTIs	No significant effect expected	No dosage adjustment necessary.
<b>Herbal Products</b>			
<b>St. John's Wort</b>	DTG	↓ DTG possible	<b>Do not coadminister.</b>
	• EVG/c/TDF/FTC • EVG plus (PI/r)	↓ EVG and COBI possible	<b>Do not coadminister.</b>
<b>Hormonal Contraceptives</b>			
<b>Hormonal Contraceptives</b>	RAL	No clinically significant effect	No dosage adjustment necessary.
<b>Norgestimate/Ethinyl Estradiol</b>	DTG	No significant effect	No dosage adjustment necessary.
	EVG/c/TDF/FTC	• Norgestimate AUC, C <sub>max</sub> , and C <sub>min</sub> ↑ >2-fold • Ethinyl estradiol AUC ↓ 25% and C <sub>min</sub> ↓ 44%	The effects of increases in progestin (norgestimate) are not fully known and can include insulin resistance, dyslipidemia, acne, and venous thrombosis. Weigh the risks and benefits of the drug, and consider alternative contraceptive method.
	EVG plus (PI/r)	↔ EVG	Refer to <a href="#">Table 19a</a> for recommendations when used with PI/r.
<b>HMG-CoA Reductase Inhibitors</b>			
<b>Atorvastatin</b>	EVG/c/TDF/FTC	↑ atorvastatin possible	Titrate statin dose slowly and use the lowest dose possible.
	EVG plus (PI/r)	↔ EVG expected	Refer to <a href="#">Table 19a</a> for dosing recommendations when used with PI/r.

**Table 19d. Drug Interactions Between Integrase Strand Transfer Inhibitors and Other Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 8 of 11)**

Concomitant Drug Class/Name	INSTI	Effect on INSTI or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>HMG-CoA Reductase Inhibitors, continued</b>			
<b>Lovastatin</b>	• EVG/c/TDF/FTC • EVG plus (PI/r)	Significant ↑ lovastatin expected	<b>Contraindicated. Do not coadminister.</b>
<b>Pitavastatin Pravastatin</b>	EVG/c/TDF/FTC	No data	No dosage recommendation
	EVG plus (PI/r)	↔ EVG expected	Refer to <a href="#">Table 19a</a> for dosing recommendations when used with PI/r.
<b>Rosuvastatin</b>	EVG/c/TDF/FTC	Rosuvastatin AUC ↑ 38% and C <sub>max</sub> ↑ 89%	Titrate statin dose slowly and use the lowest dose possible.
	EVG plus (PI/r)	↔ EVG expected	Refer to <a href="#">Table 19a</a> for dosing recommendations when used with PI/r.
<b>Simvastatin</b>	• EVG/c/TDF/FTC • EVG plus (PI/r)	Significant ↑ simvastatin expected	<b>Contraindicated. Do not coadminister.</b>
<b>Immunosuppressants</b>			
<b>Cyclosporine Everolimus Sirolimus Tacrolimus</b>	• EVG/c/TDF/FTC • EVG plus (PI/r)	↑ immunosuppressant possible	Initiate with an adjusted immuno-suppressant dose to account for potential increased concentration and monitor for toxicities. Therapeutic drug monitoring of immunosuppressant is recommended. Consult with specialist as necessary.
<b>Narcotics/Treatment for Opioid Dependence</b>			
<b>Buprenorphine</b>	EVG/c/TDF/FTC	• Buprenorphine AUC ↑ 35%, C <sub>max</sub> ↑ 12%, and C <sub>min</sub> ↑ 66% • Norbuprenorphine AUC ↑ 42%, C <sub>max</sub> ↑ 24%, and C <sub>min</sub> ↑ 57%	No dosage adjustment necessary. Clinical monitoring is recommended.
	EVG plus (PI/r)	↔ EVG expected	Refer to <a href="#">Table 19a</a> for dosing recommendations when used with PI/r.
	RAL	No significant effect	No dosage adjustment necessary.
<b>Methadone</b>	DTG	No significant effect	No dosage adjustment necessary.
	EVG/c/TDF/FTC	No significant effect	No dosage adjustment necessary.
	EVG plus (PI/r)	↓ methadone	Opioid withdrawal unlikely but may occur. Dosage adjustment of methadone is not usually required. Monitor for opioid withdrawal and increase methadone dose as clinically indicated.
	RAL	No significant effect	No dosage adjustment necessary.



**Table 19d. Drug Interactions Between Integrase Strand Transfer Inhibitors and Other Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 9 of 11)**

Concomitant Drug Class/Name	INSTI	Effect on INSTI or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>Neuroleptics</b>			
Perphenazine Risperidone Thioridazine	EVG/c/TDF/FTC	↑ neuroleptic possible	Initiate neuroleptic at a low dose. Decrease in neuroleptic dose may be necessary.
<b>PDE5 Inhibitors</b>			
Avanafil	• EVG/c/TDF/FTC • EVG plus (PI/r)	No data	<b>Coadministration is not recommended.</b>
Sildenafil	• EVG/c/TDF/FTC • EVG plus (PI/r)	↑ sildenafil expected	<p><u>For treatment of erectile dysfunction:</u></p> <ul style="list-style-type: none"> <li>Start with sildenafil 25 mg every 48 hours and monitor for adverse effects of sildenafil.</li> </ul> <p><u>For treatment of PAH:</u></p> <ul style="list-style-type: none"> <li><b>Contraindicated</b></li> </ul>
Tadalafil	• EVG/c/TDF/FTC • EVG plus (PI/r)	↑ tadalafil expected	<p><u>For treatment of erectile dysfunction:</u></p> <ul style="list-style-type: none"> <li>Start with tadalafil 5-mg dose and do not exceed a single dose of 10 mg every 72 hours. Monitor for adverse effects of tadalafil.</li> </ul> <p><u>For treatment of PAH</u></p> <p><i>In patients on EVG/c/TDF/FTC &gt;7 days:</i></p> <ul style="list-style-type: none"> <li>Start with tadalafil 20 mg once daily and increase to 40 mg once daily based on tolerability.</li> </ul> <p><i>In patients on tadalafil who require EVG/c/TDF/FTC:</i></p> <ul style="list-style-type: none"> <li>Stop tadalafil ≥24 hours before EVG/c/TDF/FTC initiation. Seven days after EVG/c/TDF/FTC initiation restart tadalafil at 20 mg once daily, and increase to 40 mg once daily based on tolerability.</li> </ul>
Vardenafil	• EVG/c/TDF/FTC • EVG plus (PI/r)	↑ vardenafil expected	Start with vardenafil 2.5 mg every 72 hours and monitor for adverse effects of vardenafil.

**Table 19d. Drug Interactions Between Integrase Strand Transfer Inhibitors and Other Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 10 of 11)**

Concomitant Drug Class/Name	INSTI	Effect on INSTI or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>Sedative/Hypnotics</b>			
Clonazepam Clorazepate Diazepam Estazolam Flurazepam	• EVG/c/TDF/FTC • EVG plus (PI/r)	↑ benzodiazepines possible	Dose reduction of benzodiazepine may be necessary. Initiate with low dose and clinically monitor.  Consider alternative benzodiazepines to diazepam, such as lorazepam, oxazepam, or temazepam.
Midazolam Triazolam	DTG	<u>With DTG 25 mg:</u> • midazolam AUC ↔	No dosage adjustment necessary.
	• EVG/c/TDF/FTC • EVG plus (PI/r)	• ↑ midazolam expected • ↑ triazolam expected	<b>Do not coadminister triazolam or oral midazolam and EVG/c/TDF/FTC or (EVG plus PI).</b>  Parenteral midazolam can be used with caution in a closely monitored setting. Consider dose reduction, especially if more than one dose is administered.
Suvorexant	• EVG/c/TDF/FTC • EVG plus (PI/r)	↑ suvorexant expected	<b>Coadministration is not recommended.</b>
Zolpidem	• EVG/c/TDF/FTC • EVG plus (PI/r)	↑ zolpidem expected	Initiate zolpidem at a low dose. Dose reduction may be necessary.
<b>Miscellaneous Drugs</b>			
Colchicine	• EVG/c/TDF/FTC • EVG plus (PI/r)	↑ colchicine expected	<b>Do not coadminister in patients with hepatic or renal impairment.</b>  <u>For treatment of gout flares:</u> • Colchicine 0.6 mg for 1 dose, followed by 0.3 mg 1 hour later. Do not repeat dose for at least 3 days.  <u>For prophylaxis of gout flares:</u> • If original dose was colchicine 0.6 mg BID, decrease to colchicine 0.3 mg once daily. If regimen was 0.6 mg once daily, decrease to 0.3 mg every other day.  <u>For treatment of Familial Mediterranean Fever:</u> • Do not exceed colchicine 0.6 mg once daily or 0.3 mg BID.

**Table 19d. Drug Interactions Between Integrase Strand Transfer Inhibitors and Other Drugs (Last updated April 8, 2015; last reviewed April 8, 2015) (page 11 of 11)**

Concomitant Drug Class/Name	INSTI	Effect on INSTI or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>Miscellaneous Drugs, continued</b>			
<b>Metformin</b>	DTG	<p><u>DTG 50 mg once daily plus metformin:</u></p> <ul style="list-style-type: none"> <li>• Metformin AUC ↑ 79%, C<sub>max</sub> ↑ 66%, and C<sub>min</sub> ↑ 9%</li> </ul> <p><u>DTG 50 mg BID plus metformin:</u></p> <ul style="list-style-type: none"> <li>• Metformin AUC ↑ 2.4 fold, C<sub>max</sub> ↑ 2 fold, and C<sub>min</sub> ↑ 14%</li> </ul>	<p>When starting metformin in patient on DTG, start at low metformin dose and titrate dose to achieve glycemic control and minimize GI symptoms.</p> <p>When starting/stopping DTG in patient on metformin, dose adjustment of metformin may be necessary to maintain optimal glycemic control and/or minimize GI symptoms.</p>
<p><b>Polyvalent Cation Supplements</b></p> <p>Mg, Al, Fe, Ca, Zn, including multivitamins with minerals</p> <p><b>Note:</b> Please refer to the Acid Reducers section in this table for recommendations on use with Al-, Mg-, and Ca-containing antacids.</p>	All INSTIs	<ul style="list-style-type: none"> <li>• ↓ INSTI possible</li> <li>• DTG ↔ when administered with Ca or Fe supplement simultaneously with food</li> </ul>	<p>If coadministration is necessary, give INSTI at least 2 hours before or at least 6 hours after supplements containing polyvalent cations, including but not limited to the following products: cation-containing laxatives; Fe, Ca, or Mg supplements; and sucralfate. Monitor for virologic efficacy.</p> <p>DTG and supplements containing Ca or Fe can be taken simultaneously with food.</p> <p>Many oral multivitamins also contain varying amounts of polyvalent cations; the extent and significance of chelation is unknown.</p>
<b>Salmeterol</b>	<ul style="list-style-type: none"> <li>• EVG/c/TDF/FTC</li> <li>• EVG plus (PI/r)</li> </ul>	↑ salmeterol possible	<b>Do not coadminister</b> because of potential increased risk of salmeterol-associated cardiovascular events.

**Key to Acronyms:** Al = aluminum; ART = antiretroviral therapy; ARV = antiretroviral; ATV/r = atazanavir/ritonavir; AUC = area under the curve; BID = twice daily; Ca = calcium; CaCO<sub>3</sub> = calcium carbonate; CCB = calcium channel blocker; C<sub>max</sub> = maximum plasma concentration; C<sub>min</sub> = minimum plasma concentration; COBI = cobicistat; CrCl = creatinine clearance; CYP = cytochrome P; DTG = dolutegravir; EVG = elvitegravir; EVG/c/TDF/FTC = elvitegravir/cobicistat/tenofovir disoproxil fumarate/emtricitabine; Fe = iron; GI = gastrointestinal; INR = international normalized ratio; INSTI = integrase strand transfer inhibitor; Mg = magnesium; PAH = pulmonary arterial hypertension; PI = protease inhibitor; PI/r = ritonavir-boosted protease inhibitor; PPI = proton pump inhibitor; RAL = raltegravir; SQV/r = saquinavir/ritonavir; SSRI = selective serotonin reuptake inhibitor; TCA = tricyclic anti-depressant; TDF = tenofovir disoproxil fumarate; Zn = zinc

**Table 19e. Drug Interactions Between CCR5 Antagonist (Maraviroc) and Other Drugs (Including Antiretroviral Agents) (Last updated April 8, 2015; last reviewed April 8, 2015) (page 1 of 3)**

Concomitant Drug Class/Name	CCR5 Antagonist	Effect on CCR5 Antagonist and/or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>Anticonvulsants</b>			
Carbamazepine Phenobarbital Phenytoin	MVC	↓ MVC possible	If used without a strong CYP3A inhibitor, use MVC 600 mg BID or an alternative antiepileptic agent.
<b>Antifungals</b>			
Itraconazole	MVC	↑ MVC possible	<u>Dose:</u> • MVC 150 mg BID
Voriconazole	MVC	↑ MVC possible	Consider dose reduction to MVC 150 mg BID.
<b>Antimycobacterials</b>			
Clarithromycin	MVC	↑ MVC possible	<u>Dose:</u> • MVC 150 mg BID
Rifabutin	MVC	↓ MVC possible	If used without a strong CYP3A inducer or inhibitor, use MVC 300 mg BID.  If used with a strong CYP3A inhibitor, use MVC 150 mg BID.
Rifampin	MVC	MVC AUC ↓ 64%	<b>Coadministration is not recommended.</b>  If coadministration is necessary, use MVC 600 mg BID.  If coadministered with a strong CYP3A inhibitor, use MVC 300 mg BID.
Rifapentine	MVC	↓ MVC expected	Do not coadminister.
<b>Hepatitis C Direct Acting Antivirals</b>			
Boceprevir	MVC	MVC AUC ↑ 202%	<u>Dose:</u> • MVC 150 mg BID
Dasabuvir plus Ombitasvir/ Paritaprevir/RTV	MVC	↑ MVC expected	<b>Do not coadminister.</b>
Ledipasvir/ Sofosbuvir	MVC	↔ MVC expected	<u>Dose:</u> • MVC 300 mg BID
Simeprevir	MVC	↔ MVC expected	<u>Dose:</u> • MVC 300 mg BID
<b>Herbal Products</b>			
St. John's Wort	MVC	↓ MVC possible	<b>Coadministration is not recommended.</b>
<b>Hormonal Contraceptives</b>			
Hormonal Contraceptives	MVC	No significant effect on ethinyl estradiol or levonorgestrel	Safe to use in combination

**Table 19e. Drug Interactions Between CCR5 Antagonist (Maraviroc) and Other Drugs (Including Antiretroviral Agents) (Last updated April 8, 2015; last reviewed April 8, 2015) (page 2 of 3)**

Concomitant Drug Class/Name	CCR5 Antagonist	Effect on CCR5 Antagonist and/or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
<b>ARV Drugs</b>			
<b>INSTIs</b>			
EVG/c/TDF/FTC	MVC	↑ MVC possible	<b>Do not coadminister.</b>
EVG + PI/r	MVC	No data	Refer to PIs listed below for dosing recommendations when MVC is used with a PI/r.
RAL	MVC	MVC AUC ↓ 21% RAL AUC ↓ 37%	<u>Dose:</u> • Standard
<b>NNRTIs</b>			
EFV	MVC	MVC AUC ↓ 45%	<u>Dose:</u> • MVC 600 mg BID
ETR	MVC	MVC AUC ↓ 53%	<u>Dose:</u> • MVC 600 mg BID in the absence of a potent CYP3A inhibitor
NVP	MVC	MVC AUC ↔	<u>Without HIV PI:</u> • MVC 300 mg BID  <u>With HIV PI (except TPV/r):</u> • MVC 150 mg BID
<b>PIs</b>			
ATV +/- RTV or COBI	MVC	<u>With Unboosted ATV:</u> • MVC AUC ↑ 257%  <u>With (ATV 300 mg Plus RTV 100 mg) Once Daily:</u> • MVC AUC ↑ 388%	<u>Dose:</u> • MVC 150 mg BID
DRV/r or DRV/c	MVC	<u>With (DRV 600 mg Plus RTV 100 mg) BID:</u> • MVC AUC ↑ 305%  <u>With (DRV 600 mg Plus RTV 100 mg) BID and ETR:</u> • MVC AUC ↑ 210%	<u>Dose:</u> • MVC 150 mg BID
FPV +/- RTV	MVC	<u>With (FPV 700 mg Plus RTV 100 mg) BID and MVC 300 mg BID:</u> • MVC AUC ↑ 149%, C <sub>min</sub> ↑ 374%  <u>With (FPV 1400 mg Plus RTV 200 mg) Once Daily and MVC 300 mg Once Daily:</u> • MVC AUC ↑ 126%, C <sub>min</sub> ↑ 80%	<u>Dose:</u> • MVC 150 mg BID
LPV/r	MVC	MVC AUC ↑ 295%  <u>With LPV/r and EFV:</u> • MVC AUC ↑ 153%	<u>Dose:</u> • MVC 150 mg BID

**Table 19e. Drug Interactions Between CCR5 Antagonist (Maraviroc) and Other Drugs (Including Antiretroviral Agents) (Last updated April 8, 2015; last reviewed April 8, 2015) (page 3 of 3)**

Concomitant Drug Class/Name	CCR5 Antagonist	Effect on CCR5 Antagonist and/or Concomitant Drug Concentrations	Dosing Recommendations and Clinical Comments
Pls, continued			
RTV	MVC	<u>With RTV 100 mg BID:</u> • MVC AUC ↑ 161%	<u>Dose:</u> • MVC 150 mg BID
SQV/r	MVC	<u>With (SQV 1000 mg Plus RTV 100 mg) BID:</u> • MVC AUC ↑ 877%  <u>With (SQV 1000 mg Plus RTV 100 mg) BID and EFV:</u> • MVC AUC ↑ 400%	<u>Dose:</u> • MVC 150 mg BID
TPV/r	MVC	<u>With (TPV 500 mg Plus RTV 200 mg) BID:</u> • MVC AUC ↔	<u>Dose:</u> • MVC 300 mg BID

**Note:** FPV is a pro-drug of APV.

**Key to Symbols:** ↑ = increase, ↓ = decrease, ↔ = no change

**Key to Acronyms:** ARV = antiretroviral; ATV = atazanavir; ATV/r = atazanavir/ritonavir; AUC = area under the curve; BID = twice daily; COBI = cobicistat; CYP = cytochrome P; DRV/c = darunavir/cobicistat; DRV/r = darunavir/ritonavir; EFV = efavirenz; ETR = etravirine; EVG = elvitegravir; FPV = fosamprenavir; FTC = emtricitabine; INSTI = integrase strand transfer inhibitor; LPV/r = lopinavir/ritonavir; MVC = maraviroc; NVP = nevirapine; PI = protease inhibitor; PK = pharmacokinetic; RAL = raltegravir; RTV = ritonavir; SQV/r = saquinavir/ritonavir; TDF = tenofovir disoproxil fumarate; TPV/r = tipranavir/ritonavir



**Table 20a. Interactions between Non-Nucleoside Reverse Transcriptase Inhibitors and Protease Inhibitors<sup>a</sup> (Last updated April 8, 2015; last reviewed April 8, 2015) (Page 1 of 3)**

**Note:** DLV, IDV, and NFV are not included in this table. Refer to the DLV, IDV, and NFV Food and Drug Administration package inserts for information regarding drug interactions.

PIs		NNRTIs			
		EFV	ETR	NVP	RPV <sup>a</sup>
ATV Unboosted	<b>PK Data</b>	EFV: no significant change ATV AUC ↓ 74%	ETR AUC ↑ 50% and C <sub>min</sub> ↑ 58% ATV AUC ↓ 17% and C <sub>min</sub> ↓ 47%	↓ ATV possible	↑ RPV possible
	<b>Dose</b>	<b>Do not coadminister.</b>	<b>Do not coadminister.</b>	<b>Do not coadminister.</b>	Standard doses
ATV/c	<b>PK Data</b>	↓ ATV ↓ COBI	↓ ATV ↓ COBI	↓ COBI	↑ RPV possible ↔ ATV expected
	<b>Dose</b>	EFV standard dose <u>In ART-Naive Patients:</u> • ATV 400 mg plus COBI 150 mg Once Daily <b>Do not coadminister in ART-experienced patients.</b>	<b>Do not coadminister.</b>	<b>Do not coadminister.</b>	Standard doses
ATV/r	<b>PK Data</b>	(ATV 300 mg plus RTV 100 mg) Once Daily: • ATV concentrations are similar to those with unboosted ATV without EFV.	(ATV 300 mg plus RTV 100 mg) Once Daily: • ETR AUC and C <sub>min</sub> both ↑ ~30% • ATV AUC ↔ and C <sub>min</sub> ↓ 18%	(ATV 300 mg plus RTV 100 mg) Once Daily: • ATV AUC ↓ 42% and C <sub>min</sub> ↓ 72% • NVP AUC ↑ 25%	↑ RPV possible
	<b>Dose</b>	EFV standard dose <u>In ART-Naive Patients:</u> • (ATV 400 mg plus RTV 100 mg) Once Daily <b>Do not coadminister in ART-experienced patients.</b>	ETR standard dose (ATV 300 mg plus RTV 100 mg) Once Daily	<b>Do not coadminister.</b>	Standard doses
DRV/c	<b>PK Data</b>	↓ DRV possible ↓ COBI possible	Effect on DRV unknown ↓ COBI possible	Effect on DRV unknown ↓ COBI possible	↔ DRV expected ↑ RPV possible
	<b>Dose</b>	<b>Do not coadminister.</b>	<b>Do not coadminister.</b>	<b>Do not coadminister.</b>	Standard doses

**Table 20a. Interactions between Non-Nucleoside Reverse Transcriptase Inhibitors, and Protease Inhibitors<sup>a</sup>** (Last updated April 8, 2015; last reviewed April 8, 2015) (Page 2 of 3)

PIs		NNRTIs			
		EFV	ETR	NVP	RPV <sup>a</sup>
DRV/r	PK Data	<u>With (DRV 300 mg plus RTV 100 mg) BID:</u> <ul style="list-style-type: none"> <li>• EFV AUC ↑ 21%</li> <li>• DRV AUC ↓ 13% and C<sub>min</sub> ↓ 31%</li> </ul>	<u>ETR 100 mg BID with (DRV 600 mg plus RTV 100 mg) BID:</u> <ul style="list-style-type: none"> <li>• ETR AUC ↓ 37% and C<sub>min</sub> ↓ 49%</li> <li>• DRV: no significant change</li> </ul>	<u>With (DRV 400 mg plus RTV 100 mg) BID:</u> <ul style="list-style-type: none"> <li>• NVP AUC ↑ 27% and C<sub>min</sub> ↑ 47%</li> <li>• DRV AUC ↑ 24%<sup>b</sup></li> </ul>	<u>RPV 150 mg Once Daily with (DRV 800 mg plus RTV 100 mg) Once Daily:</u> <ul style="list-style-type: none"> <li>• RPV AUC ↑ 130% and C<sub>min</sub> ↑ 178%</li> <li>• DRV: no significant change</li> </ul>
	Dose	Clinical significance unknown. Use standard doses and monitor patient closely. Consider monitoring drug levels.	Standard doses  Safety and efficacy of this combination, despite reduced ETR concentration, have been established in a clinical trial.	Standard doses	Standard doses
FPV +/- RTV	PK Data	<u>With (FPV 1400 mg plus RTV 200 mg) Once Daily:</u> <ul style="list-style-type: none"> <li>• APV C<sub>min</sub> ↓ 36%</li> </ul>	<u>With (FPV 700 mg plus RTV 100 mg) BID:</u> <ul style="list-style-type: none"> <li>• APV AUC ↑ 69% and C<sub>min</sub> ↑ 77%</li> </ul>	<u>With Unboosted FPV 1400 mg BID:</u> <ul style="list-style-type: none"> <li>• NVP AUC ↑ 29%</li> <li>• APV AUC ↓ 33%</li> </ul> <u>With (FPV 700 mg plus RTV 100 mg) BID:</u> <ul style="list-style-type: none"> <li>• NVP C<sub>min</sub> ↑ 22%</li> </ul>	<u>With Boosted and Unboosted FPV:</u> <ul style="list-style-type: none"> <li>• ↑ RPV possible</li> </ul>
	Dose	(FPV 1400 mg plus RTV 300 mg) Once Daily <b>or</b> (FPV 700 mg plus RTV 100 mg) BID  EFV standard dose	<b>Do not coadminister with FPV +/- RTV.</b>	(FPV 700 mg plus RTV 100 mg) BID  NVP standard dose	Standard doses
LPV/r	PK Data	<u>With LPV/r Tablets 500/125 mg<sup>c</sup> BID:</u> <ul style="list-style-type: none"> <li>• LPV concentration similar to that with LPV/r 400/100 mg BID without EFV</li> </ul>	<u>With LPV/r Tablets:</u> <ul style="list-style-type: none"> <li>• ETR AUC ↓ 35% (comparable to the decrease with DRV/r)</li> <li>• LPV AUC ↓ 13%</li> </ul>	<u>With LPV/r Capsules:</u> <ul style="list-style-type: none"> <li>• LPV AUC ↓ 27% and C<sub>min</sub> ↓ 51%</li> </ul>	<u>RPV 150 mg Once Daily with LPV/r Capsules:</u> <ul style="list-style-type: none"> <li>• RPV AUC ↑ 52% and C<sub>min</sub> ↑ 74%</li> <li>• LPV no significant change</li> </ul>
	Dose	LPV/r tablets 500/125 mg <sup>c</sup> BID; LPV/r oral solution 533/133 mg BID  EFV standard dose	Standard doses	LPV/r tablets 500/125 mg <sup>c</sup> BID; LPV/r oral solution 533/133 mg BID  NVP standard dose	Standard doses

**Table 20a. Interactions between Non-Nucleoside Reverse Transcriptase Inhibitors, and Protease Inhibitors<sup>a</sup> (Last updated April 8, 2015; last reviewed April 8, 2015) (Page 3 of 3)**

PIs		NNRTIs			
		EFV	ETR	NVP	RPV <sup>a</sup>
<b>SQV</b> Always use with RTV	<b>PK Data</b>	<u>With SQV 1200 mg TID:</u> <ul style="list-style-type: none"> <li>• EFV AUC ↓ 12%</li> <li>• SQV AUC ↓ 62%</li> </ul>	<u>With (SQV 1000 mg plus RTV 100 mg) BID:</u> <ul style="list-style-type: none"> <li>• ETR AUC ↓ 33% and C<sub>min</sub> ↓ 29%</li> <li>• SQV AUC ↔</li> </ul> ↓ ETR levels similar to reduction with DRV/r	<u>With SQV 600 mg TID:</u> <ul style="list-style-type: none"> <li>• NVP: no significant change</li> <li>• SQV AUC ↓ 24%</li> </ul>	↑ RPV possible
	<b>Dose</b>	(SQV 1000 mg plus RTV 100 mg) BID	(SQV 1000 mg plus RTV 100 mg) BID	Dose with SQV/r not established	Standard doses
<b>TPV</b> Always use with RTV	<b>PK Data</b>	<u>With (TPV 500 mg plus RTV 100 mg) BID:</u> <ul style="list-style-type: none"> <li>• EFV no significant change</li> <li>• TPV AUC ↓ 31% and C<sub>min</sub> ↓ 42%</li> </ul> <u>With (TPV 750 mg plus RTV 200 mg) BID:</u> <ul style="list-style-type: none"> <li>• EFV: no significant change</li> <li>• TPV: no significant change</li> </ul>	<u>With (TPV 500 mg plus RTV 200 mg) BID:</u> <ul style="list-style-type: none"> <li>• ETR AUC ↓ 76% and C<sub>min</sub> ↓ 82%</li> <li>• TPV AUC ↑ 18% and C<sub>min</sub> ↑ 24%</li> </ul>	<u>With (TPV 250 mg plus RTV 200 mg) BID or with (TPV 750 mg plus RTV 100 mg) BID:</u> <ul style="list-style-type: none"> <li>• NVP: no significant change</li> <li>• TPV: no data</li> </ul>	↑ RPV possible
	<b>Dose</b>	Standard doses	<b>Do not coadminister.</b>	Standard doses	Standard doses

<sup>a</sup> Approved dose for RPV is 25 mg once daily. Most PK studies were performed using 75 mg to 150 mg RPV per dose.

<sup>b</sup> Based on between-study comparison.

<sup>c</sup> Use a combination of two LPV/r 200 mg/50 mg tablets plus one LPV/r 100 mg/25 mg tablet to make a total dose of LPV/r 500 mg/125 mg.

**Key to Symbols:** ↑ = increase, ↓ = decrease, ↔ = no change

**Key to Acronyms:** APV = amprenavir; ART = antiretroviral therapy; ATV = atazanavir; ATV/c = atazanavir/cobicistat; AUC = area under the curve; BID = twice daily; C<sub>max</sub> = maximum plasma concentration; C<sub>min</sub> = minimum plasma concentration; CYP = cytochrome P; DLV = delavirdine; DRV = darunavir; DRV/c = darunavir/cobicistat; DRV/r = darunavir/ritonavir; EFV = efavirenz; ETR = etravirine; FDA = Food and Drug Administration; FPV = fosamprenavir; IDV = indinavir; LPV = lopinavir; LPV/r = lopinavir/ritonavir; NFV = nelfinavir; NVP = nevirapine; PK = pharmacokinetic; RPV = rilpivirine; RTV = ritonavir; SQV = saquinavir; SQV/r = saquinavir/ritonavir; TID = three times a day; TPV = tipranavir

**Table 20b. Interactions Between Integrase Strand Transfer Inhibitors and Non-Nucleoside Reverse Transcriptase Inhibitors or Protease Inhibitors** (Last updated April 8, 2015; last reviewed April 8, 2015) (page 1 of 4)

ARV Drugs by Drug Class		INSTIs			
		DTG	EVG/c/TDF/FTC	EVG (EVG must be given with a PI/r.)	RAL
<b>NNRTIs</b>					
EFV	PK Data	With DTG 50 mg once daily: • DTG AUC ↓ 57% and C <sub>min</sub> ↓ 75%	↑ or ↓ EVG, COBI, EFV possible	↓ EVG expected	<u>RAL</u> : • AUC ↓ 36%
	Dose	<u>In patients without INSTI resistance:</u> • DTG 50 mg BID  <u>In patients with certain INSTI-associated resistance<sup>a</sup> or clinically suspected INSTI resistance:</u> • <b>Consider alternative combination.</b>	<b>Do not coadminister.</b>	<b>Do not coadminister.</b>	Standard doses
ETR	PK Data	<u>ETR 200 mg BID plus DTG 50 mg once daily:</u> • DTG AUC ↓ 71% and C <sub>min</sub> ↓ 88%  <u>ETR 200 mg BID with (DRV 600 mg plus RTV 100 mg) BID and DTG 50 mg once daily:</u> • DTG AUC ↓ 25% and C <sub>min</sub> ↓ 37%  <u>ETR 200 mg BID with (LPV 400 mg plus RTV 100 mg) BID and DTG 50 mg once daily:</u> • DTG AUC ↑ 11% and C <sub>min</sub> ↑ 28%	↑ or ↓ EVG, COBI, ETR possible	No significant interaction between EVG/r and ETR	• ETR C <sub>min</sub> ↓ 17% • RAL C <sub>min</sub> ↓ 34%
	Dose	<b>Do not coadminister ETR and DTG without concurrently administering ATV/r, DRV/r, or LPV/r.</b>  <u>In patients without INSTI resistance:</u> • DTG 50 mg once daily with ETR (concurrently with ATV/r, DRV/r, or LPV/r)  <u>In patients with certain INSTI-associated resistance<sup>a</sup> or clinically suspected INSTI resistance:</u> • DTG 50 mg BID with ETR (concurrently with ATV/r, DRV/r, or LPV/r)	<b>Do not coadminister.</b>	May coadminister EVG with ETR plus (ATV/r, DRV/r, or LPV/r)  <u>EVG:</u> • Standard dose depending on the concomitant PI (see below)	Standard doses

**Table 20b. Interactions Between Integrase Strand Transfer Inhibitors and Non-Nucleoside Reverse Transcriptase Inhibitors or Protease Inhibitors (Last updated April 8, 2015; last reviewed April 8, 2015) (page 2 of 4)**

ARV Drugs by Drug Class		INSTIs			
		DTG	EVG/c/TDF/FTC	EVG (EVG must be given with a PI/r.)	RAL
NNRTIs, continued					
NVP	PK Data	↓ DTG possible	↑ or ↓ EVG, COBI, NVP possible	↓ EVG possible	No data
	Dose	Do not coadminister.	Do not coadminister.	Do not coadminister.	Standard doses
RPV	PK Data	With DTG 50 mg once daily: • DTG AUC ↔ and C <sub>min</sub> ↑ 22% • RPV AUC ↔ and C <sub>min</sub> ↑ 21%	↑ or ↓ EVG, COBI, RPV possible	↑ RPV expected	• RPV ↔ • RAL C <sub>min</sub> ↑ 27%
	Dose	Standard doses	Do not coadminister.	EVG: • Standard dose depending on the concomitant PI (see below)  RPV: • Standard dose	Standard doses
PIs					
ATV/c	PK Data	No data	ATV/c plus EVG/c: • No data	No data	No data
	Dose	Standard doses	Do not coadminister.	Do not coadminister.	Standard doses
ATV +/- RTV	PK Data	Unboosted ATV plus DTG 30 mg once daily: • DTG AUC ↑ 91% and C <sub>min</sub> ↑ 180%  (ATV 300 mg plus RTV 100 mg) once daily plus DTG 30 mg once daily: • DTG AUC ↑ 62% and C <sub>min</sub> ↑ 121%	↑ or ↓ EVG, COBI, ATV possible	EVG 85 mg with (ATV 300 mg plus RTV 100 mg) once daily: • EVG AUC ↔ and C <sub>min</sub> ↑ 38% • ATV AUC and C <sub>min</sub> ↔	With unboosted ATV: • RAL AUC ↑ 72%  With (ATV 300 mg plus RTV 100 mg) once daily: • RAL AUC ↑ 41%
	Dose	Standard doses	Do not coadminister.	• EVG 85 mg once daily • (ATV 300 mg plus RTV 100 mg) once daily	Standard doses
DRV/c	PK Data	No data.	DRV/c plus EVG/c: • ↓ EVG possible	No data.	No data
	Dose	Standard doses	Do not coadminister.	Do not coadminister.	Standard doses

**Table 20b. Interactions Between Integrase Strand Transfer Inhibitors and Non-Nucleoside Reverse Transcriptase Inhibitors or Protease Inhibitors (Last updated April 8, 2015; last reviewed April 8, 2015) (page 3 of 4)**

ARV Drugs by Drug Class		INSTIs			
		DTG	EVG/c/TDF/FTC	EVG (EVG must be given with a PI/r.)	RAL
PIs, continued					
DRV/r	PK Data	<u>(DRV 600 mg plus RTV 100 mg) BID with DTG 30 mg once daily:</u> • DTG AUC ↓ 22% and C <sub>min</sub> ↓ 38%	↑ or ↓ EVG, COBI, DRV possible	<u>EVG 125 mg once daily with (DRV 600 mg plus RTV 100 mg) BID:</u> • EVG AUC and C <sub>min</sub> ↔ • DRV AUC and C <sub>min</sub> ↔	<u>With (DRV 600 mg plus RTV 100 mg) BID:</u> • RAL AUC ↓ 29% and C <sub>min</sub> ↑ 38%
	Dose	<u>Standard doses:</u> • Once or twice daily dosing of DRV/r	<b>Do not coadminister.</b>	• EVG 150 mg once daily • (DRV 600 mg plus RTV 100 mg) BID	Standard doses
FPV +/- RTV	PK Data	<u>With (FPV 700 mg plus RTV 100 mg) BID and DTG 50 mg once daily:</u> • DTG AUC ↓ 35% and C <sub>min</sub> ↓ 49%	↑ or ↓ EVG, COBI, FPV possible	No significant interaction with FPV and EVG	FPV: No significant effect
	Dose	<u>In patients without INSTI resistance:</u> • DTG 50 mg BID  <u>In patients with certain INSTI-associated resistance<sup>a</sup> or clinically suspected INSTI resistance:</u> • <b>Consider alternative combination.</b>	<b>Do not coadminister.</b>	• EVG 150 mg once daily • (FPV 700 mg plus RTV 100 mg) BID	Standard doses
LPV/r	PK Data	<u>With (LPV 400 mg plus RTV 100 mg) BID and DTG 30 mg once daily:</u> • DTG: no significant effect	↑ or ↓ EVG, COBI, LPV possible  RTV and COBI have similar effects on CYP3A.	<u>EVG 125 mg once daily with (LPV 400 mg plus RTV 100 mg) BID:</u> • EVG AUC ↑ 75% and C <sub>min</sub> ↑ 138% • LPV AUC and C <sub>min</sub> ↔	• ↓ RAL • ↔ LPV/r
	Dose	<u>Standard doses:</u> • Once or twice daily dosing of LPV/r	<b>Do not coadminister.</b>	• EVG 85 mg once daily • (LPV 400 mg plus RTV 100 mg) BID	Standard doses
SQV/r	PK Data	No data	↑ or ↓ EVG, COBI, SQV possible  RTV and COBI have similar effects on CYP3A.	No data	No data
	Dose	Standard doses	<b>Do not coadminister.</b>	No dosage recommendation	Standard doses



**Table 20b. Interactions Between Integrase Strand Transfer Inhibitors and Non-Nucleoside Reverse Transcriptase Inhibitors or Protease Inhibitors (Last updated April 8, 2015; last reviewed April 8, 2015) (page 4 of 4)**

ARV Drugs by Drug Class		INSTIs			
		DTG	EVG/c/TDF/FTC	EVG (EVG must be given with a PI/r.)	RAL
PIs, continued					
TPV/r	PK Data	With (TPV 500 mg plus RTV 200 mg) BID and DTG 50 mg once daily: • DTG AUC ↓ 59% and C <sub>min</sub> ↓ 76%	↑ or ↓ EVG, COBI, TPV possible  RTV and COBI have similar effects on CYP3A.	EVG 200 mg once daily with (TPV 500 mg plus RTV 200 mg) BID: • EVG AUC and C <sub>min</sub> ↔ • TPV AUC and C <sub>min</sub> ↔	With (TPV 500 mg plus RTV 200 mg) BID: • RAL AUC ↓ 24%
	Dose	In patients without INSTI resistance: • DTG 50 mg BID  In patients with certain INSTI-associated resistance or clinically suspected INSTI resistance: • Consider alternative combination.	Do not coadminister.	• EVG 150 mg once daily • (TPV 500 mg plus RTV 200 mg) BID	Standard doses

<sup>a</sup> Refer to dolutegravir product labeling for details.

**Key to Symbols:** ↑ = increase; ↓ = decrease; ↔ = no change

**Key to Abbreviations:** ARV = antiretroviral; ATV = atazanavir; ATV/c = atazanavir/cobicistat; ATV/r = atazanavir/ritonavir; AUC = area under the curve; BID = twice daily; C<sub>min</sub> = minimum plasma concentration; COBI, c = cobicistat; CYP = cytochrome P; DRV = darunavir; DRV/c = darunavir/cobicistat; DRV/r = darunavir/ritonavir; DTG = dolutegravir; EFV = efavirenz; ETR = etravirine; EVG = elvitegravir; EVG/c = elvitegravir/cobicistat; EVG/c/TDF/FTC = elvitegravir/cobicistat/tenofovir disoproxil fumarate/emtricitabine; EVG/r = elvitegravir/ritonavir; FPV = fosamprenavir; INSTI = integrase strand transfer inhibitor; LPV = lopinavir; LPV/r = lopinavir/ritonavir; NNRTI = non-nucleoside reverse transcriptase inhibitor; NVP = nevirapine; PI = protease inhibitor; PI/r = ritonavir-boosted protease inhibitor; PK = pharmacokinetic; RAL = raltegravir; RPV = rilpivirine; RTV = ritonavir; SQV = saquinavir; SQV/r = saquinavir/ritonavir; TPV = tipranavir; TPV/r = tipranavir/ritonavir

## Preventing Secondary Transmission of HIV (Last updated March 27, 2012; last reviewed March 27, 2012)

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Despite substantial advances in prevention and treatment of HIV infection in the United States, the rate of new infections has remained stable.<sup>1-2</sup> Although earlier prevention interventions mainly were behavioral, recent data demonstrate the strong impact of antiretroviral therapy (ART) on secondary HIV transmission. The most effective strategy to stem the spread of HIV will probably be a combination of behavioral, biological, and pharmacological interventions.<sup>3</sup>

### Prevention Counseling

Counseling and related behavioral interventions for those living with HIV infection can reduce behaviors associated with secondary transmission of HIV. Each patient encounter offers the clinician an opportunity to reinforce HIV prevention messages, but multiple studies show that prevention counseling is frequently neglected in clinical practice.<sup>4-5</sup> Although delivering effective prevention interventions in a busy practice setting may be challenging, clinicians should be aware that patients often look to their providers for messages about HIV prevention. Multiple approaches to prevention counseling are available, including formal guidance from the Centers for Disease Control and Prevention (CDC) for incorporating HIV prevention into medical care settings. Such interventions have been demonstrated to be effective in changing sexual risk behavior<sup>6-8</sup> and can reinforce self-directed behavior change early after diagnosis.<sup>9</sup>

CDC has identified several prevention interventions for individuals infected with HIV that meet stringent criteria for efficacy and scientific rigor (<http://www.cdc.gov/hiv/topics/research/prs/index.htm>). The following three interventions have proven effective in treatment settings and can be delivered by providers as brief messages during clinic visits:

- Partnership for Health (<http://effectiveinterventions.org/en/Interventions/PfH.aspx>),
- Options (<http://www.cdc.gov/hiv/topics/research/prs/resources/factsheets/options.htm>),
- Positive Choice (<http://www.cdc.gov/hiv/topics/research/prs/resources/factsheets/positive-choice.htm>).

In addition, CDC's "Prevention Is Care" campaign (<http://www.actagainstaids.org/provider/pic/index.html>) helps providers (and members of a multidisciplinary care team) integrate simple methods to prevent transmission by HIV-infected individuals into routine care. These prevention interventions are designed to reduce the risk of secondary HIV transmission through sexual contact. The interventions are designed generally for implementation at the community or group level, but some can be adapted and administered in clinical settings by a multidisciplinary care team.

### Need for Screening for High-Risk Behaviors

The primary care visit provides an opportunity to screen patients for ongoing high-risk drug and sexual behaviors for transmitting HIV infection. Routine screening and symptom-directed testing for and treatment of sexually transmitted diseases (STDs), as recommended by CDC,<sup>10</sup> remain essential adjuncts to prevention counseling. Genital ulcers may facilitate HIV transmission and STDs may increase HIV viral load in plasma and genital secretions.<sup>7, 11-13</sup> They also provide objective evidence of unprotected sexual activity, which should prompt prevention counseling.

The contribution of substance and alcohol use to HIV risk behaviors and transmission has been well established in multiple populations,<sup>14-18</sup> therefore, effective counseling for injection and noninjection drug users is essential to prevent HIV transmission. Identifying the substance(s) of use is important because HIV

prevalence, transmission risk, risk behaviors, transmission rates, and potential for pharmacologic intervention all vary according to the type of substance used.<sup>19-21</sup> Risk-reduction strategies for injection drug users (IDUs), in addition to condom use, include needle exchange and instructions on cleaning drug paraphernalia. Evidence supporting the efficacy of interventions to reduce injection drug use risk behavior also exists. Interventions include both behavioral strategies<sup>14-15, 22</sup> and opiate substitution treatment with methadone or buprenorphine.<sup>23-24</sup> No successful pharmacologic interventions have been found for cocaine and methamphetamine users; cognitive and behavioral interventions demonstrate the greatest effect on reducing the risk behaviors of these users.<sup>25-27</sup> Given the significant impact of cocaine and methamphetamine on sexual risk behavior, reinforcement of sexual risk-reduction strategies is important.<sup>14-18, 28</sup>

## Antiretroviral Therapy as Prevention

ART can play an important role in preventing HIV transmission. Lower levels of plasma HIV RNA have been associated with decreases in the concentration of virus in genital secretions.<sup>29-32</sup> Observational studies have demonstrated the association between low serum or genital HIV RNA and a decreased rate of HIV transmission among serodiscordant heterosexual couples.<sup>29, 33-34</sup> Ecological studies of communities with relatively high concentrations of men who have sex with men (MSM) and IDUs suggest increased use of ART is associated with decreased community viral load and reduced rates of new HIV diagnoses.<sup>35-37</sup> These data suggest that the risk of HIV transmission is low when an individual's viral load is below 400 copies/mL,<sup>35, 38</sup> but the threshold below which transmission of the virus becomes impossible is unknown. Furthermore, to be effective at preventing transmission it is assumed that: (1) ART is capable of durably and continuously suppressing viremia; (2) adherence to an effective ARV regimen is high; and (3) there is an absence of a concomitant STD. Importantly, detection of HIV RNA in genital secretions has been documented in individuals with controlled plasma HIV RNA and data describing a differential in concentration of most ARV drugs in the blood and genital compartments exist.<sup>30, 39</sup> At least one case of HIV transmission from a patient with suppressed plasma viral load to a monogamous uninfected sexual partner has been reported.<sup>40</sup>

In the HPTN 052 trial in HIV-discordant couples, the HIV-infected partners who were ART naive and had CD4 counts between 350 and 550 cells/mm<sup>3</sup> were randomized to initiate or delay ART. In this study, those who initiated ART had a 96% reduction in HIV transmission to the uninfected partners.<sup>3</sup> Almost all of the participants were in heterosexual relationships, all participants received risk-reduction counseling, and the absolute number of transmission events was low: 1 among ART initiators and 27 among ART delayers. Over the course of the study virologic failure rates were less than 5%, a value much lower than generally seen in individuals taking ART for their own health. These low virologic failure rates suggest high levels of adherence to ART in the study, which may have been facilitated by the frequency of study follow-up (study visits were monthly) and by participants' sense of obligation to protect their uninfected partners. Therefore, caution is indicated when interpreting the extent to which ART for the HIV-infected partner protects seronegative partners in contexts where adherence and, thus, rates of continuous viral suppression, may be lower. Furthermore, for HIV-infected MSM and IDUs, biological and observational data suggest suppressive ART also should protect against transmission, but the actual extent of protection has not been established.

Rates of HIV risk behaviors can increase coincidentally with the availability of potent combination ART, in some cases almost doubling compared with rates in the era prior to highly effective therapy.<sup>9</sup> A meta-analysis demonstrated that the prevalence of unprotected sex acts was increased in HIV-infected individuals who believed that receiving ART or having a suppressed viral load protected against transmitting HIV.<sup>41</sup> Attitudinal shifts away from safer sexual practices since the availability of potent ART underscore the role of provider-initiated HIV prevention counseling. With wider recognition that effective treatment decreases the risk of HIV transmission, it is particularly important for providers to help patients understand that a sustained viral load below the limits of detection will dramatically reduce but does not absolutely assure the absence of

HIV in the genital and blood compartments and, hence, the inability to transmit HIV to others.<sup>41-42</sup>

Maximal suppression of viremia not only depends on the potency of the ARV regimen used but also on the patient's adherence to prescribed therapy. Suboptimal adherence can lead to viremia that not only harms the patient but also increases his/her risk of transmitting HIV (including drug-resistant strains) via sex or needle sharing. Screening for and treating behavioral conditions that can impact adherence, such as depression and alcohol and substance use, improve overall health and reduce the risk of secondary transmission.

## Summary

Consistent and effective use of ART resulting in a sustained reduction in viral load in conjunction with consistent condom usage, safer sex and drug use practices, and detection and treatment of STDs are essential tools for prevention of sexual and blood-borne transmission of HIV. Given these important considerations, medical visits provide a vital opportunity to reinforce HIV prevention messages, discuss sex- and drug-related risk behaviors, diagnose and treat intercurrent STDs, review the importance of medication adherence, and foster open communication between provider and patient.

## References

1. Prejean J, Song R, Hernandez A, et al. Estimated HIV incidence in the United States, 2006-2009. *PLoS One*. 2011;6(8):e17502.
2. Centers for Disease Control and Prevention. HIV Surveillance Report <http://www.cdc.gov/hiv/topics/surveillance/resources/reports/>. 2009. Published February 2011. Accessed December 7, 2011.
3. Cohen MS, Chen YQ, McCauley M, et al. Prevention of HIV-1 infection with early antiretroviral therapy. *N Engl J Med*. Aug 11 2011;365(6):493-505.
4. Mayer KH, Safren SA, Gordon CM. HIV care providers and prevention: opportunities and challenges. *J Acquir Immune Defic Syndr*. Oct 1 2004;37(Suppl 2):S130-132.
5. Morin SF, Koester KA, Steward WT, et al. Missed opportunities: prevention with HIV-infected patients in clinical care settings. *J Acquir Immune Defic Syndr*. Aug 1 2004;36(4):960-966.
6. Metsch LR, McCoy CB, Miles CC, Wohler B. Prevention myths and HIV risk reduction by active drug users. *AIDS Educ Prev*. Apr 2004;16(2):150-159.
7. Johnson WD, Diaz RM, Flanders WD, et al. Behavioral interventions to reduce risk for sexual transmission of HIV among men who have sex with men. *Cochrane Database Syst Rev*. 2008(3):CD001230.
8. Centers for Disease Control and Prevention (CDC). Evolution of HIV/AIDS prevention programs—United States, 1981-2006. *MMWR Morb Mortal Wkly Rep*. Jun 2 2006;55(21):597-603.
9. Gorbach PM, Drumright LN, Daar ES, Little SJ. Transmission behaviors of recently HIV-infected men who have sex with men. *J Acquir Immune Defic Syndr*. May 2006;42(1):80-85.
10. Workowski KA, Berman S. Sexually transmitted diseases treatment guidelines, 2010. *MMWR Recomm Rep*. Dec 17 2010;59(RR-12):1-110.
11. Tanton C, Weiss HA, Le Goff J, et al. Correlates of HIV-1 genital shedding in Tanzanian women. *PLoS One*. 2011;6(3):e17480.
12. Wright TC, Jr., Subbarao S, Ellerbrock TV, et al. Human immunodeficiency virus 1 expression in the female genital tract in association with cervical inflammation and ulceration. *Am J Obstet Gynecol*. Feb 2001;184(3):279-285.
13. Schacker T, Ryncarz AJ, Goddard J, Diem K, Shaughnessy M, Corey L. Frequent recovery of HIV-1 from genital herpes simplex virus lesions in HIV-1-infected men. *JAMA*. Jul 1 1998;280(1):61-66.

14. Celentano DD, Latimore AD, Mehta SH. Variations in sexual risks in drug users: emerging themes in a behavioral context. *Curr HIV/AIDS Rep*. Nov 2008;5(4):212-218.
15. Mitchell MM, Latimer WW. Unprotected casual sex and perceived risk of contracting HIV among drug users in Baltimore, Maryland: evaluating the influence of non-injection versus injection drug user status. *AIDS Care*. Feb 2009;21(2):221-230.
16. Colfax G, Coates TJ, Husnik MJ, et al. Longitudinal patterns of methamphetamine, popper (amyl nitrite), and cocaine use and high-risk sexual behavior among a cohort of san francisco men who have sex with men. *J Urban Health*. Mar 2005;82(1 Suppl 1):i62-70.
17. Mimiaga MJ, Reisner SL, Fontaine YM, et al. Walking the line: stimulant use during sex and HIV risk behavior among Black urban MSM. *Drug Alcohol Depend*. Jul 1 2010;110(1-2):30-37.
18. Ostrow DG, Plankey MW, Cox C, et al. Specific sex drug combinations contribute to the majority of recent HIV seroconversions among MSM in the MACS. *J Acquir Immune Defic Syndr*. Jul 1 2009;51(3):349-355.
19. Sterk CE, Theall KP, Elifson KW. Who's getting the message? Intervention response rates among women who inject drugs and/or smoke crack cocaine. *Prev Med*. Aug 2003;37(2):119-128.
20. Sterk CE, Theall KP, Elifson KW, Kidder D. HIV risk reduction among African-American women who inject drugs: a randomized controlled trial. *AIDS Behav*. Mar 2003;7(1):73-86.
21. Strathdee SA, Sherman SG. The role of sexual transmission of HIV infection among injection and non-injection drug users. *J Urban Health*. Dec 2003;80(4 Suppl 3):iii7-14.
22. Copenhaver MM, Johnson BT, Lee IC, Harman JJ, Carey MP. Behavioral HIV risk reduction among people who inject drugs: meta-analytic evidence of efficacy. *J Subst Abuse Treat*. Sep 2006;31(2):163-171.
23. Hartel DM, Schoenbaum EE. Methadone treatment protects against HIV infection: two decades of experience in the Bronx, New York City. *Public Health Rep*. Jun 1998;113(Suppl 1):107-115.
24. Metzger DS, Navaline H, Woody GE. Drug abuse treatment as AIDS prevention. *Public Health Rep*. Jun 1998;113(Suppl 1):97-106.
25. Crawford ND, Vlahov D. Progress in HIV reduction and prevention among injection and noninjection drug users. *J Acquir Immune Defic Syndr*. Dec 2010;55(Suppl 2):S84-87.
26. Shoptaw S, Heinzerling KG, Rotheram-Fuller E, et al. Randomized, placebo-controlled trial of bupropion for the treatment of methamphetamine dependence. *Drug Alcohol Depend*. Aug 1 2008;96(3):222-232.
27. Heinzerling KG, Swanson AN, Kim S, et al. Randomized, double-blind, placebo-controlled trial of modafinil for the treatment of methamphetamine dependence. *Drug Alcohol Depend*. Jun 1 2010;109(1-3):20-29.
28. Centers for Disease Control and Prevention. Methamphetamine Use and Risk for HIV/AIDS. Atlanta, GA: Centers for Disease Control and Prevention, US Dept. of Health and Human Services. Last Modified: May 3, 2007.
29. Baeten JM, Kahle E, Lingappa JR, et al. Genital HIV-1 RNA predicts risk of heterosexual HIV-1 transmission. *Sci Transl Med*. Apr 6 2011;3(77):77ra29.
30. Sheth PM, Kovacs C, Kemal KS, et al. Persistent HIV RNA shedding in semen despite effective antiretroviral therapy. *AIDS*. Sep 24 2009;23(15):2050-2054.
31. Graham SM, Holte SE, Peshu NM, et al. Initiation of antiretroviral therapy leads to a rapid decline in cervical and vaginal HIV-1 shedding. *AIDS*. Feb 19 2007;21(4):501-507.
32. Vernazza PL, Troiani L, Flepp MJ, et al. Potent antiretroviral treatment of HIV-infection results in suppression of the seminal shedding of HIV. The Swiss HIV Cohort Study. *AIDS*. Jan 28 2000;14(2):117-121.
33. Hughes JP, Baeten JM, Lingappa JR, et al. Determinants of Per-Coital-Act HIV-1 Infectivity Among African HIV-1-Serodiscordant Couples. *J Infect Dis*. Feb 2012;205(3):358-365.
34. Quinn TC, Wawer MJ, Sewankambo N, et al. Viral load and heterosexual transmission of human immunodeficiency virus type 1. Rakai Project Study Group. *N Engl J Med*. Mar 30 2000;342(13):921-929.

35. Das M, Chu PL, Santos GM, et al. Decreases in community viral load are accompanied by reductions in new HIV infections in San Francisco. *PLoS One*. 2010;5(6):e11068.
36. Montaner JS, Lima VD, Barrios R, et al. Association of highly active antiretroviral therapy coverage, population viral load, and yearly new HIV diagnoses in British Columbia, Canada: a population-based study. *Lancet*. Aug 14 2010;376(9740):532-539.
37. Porco TC, Martin JN, Page-Shafer KA, et al. Decline in HIV infectivity following the introduction of highly active antiretroviral therapy. *AIDS*. Jan 2 2004;18(1):81-88.
38. Attia S, Egger M, Muller M, Zwahlen M, Low N. Sexual transmission of HIV according to viral load and antiretroviral therapy: systematic review and meta-analysis. *AIDS*. Jul 17 2009;23(11):1397-1404.
39. Cu-Uvin S, DeLong AK, Venkatesh KK, et al. Genital tract HIV-1 RNA shedding among women with below detectable plasma viral load. *AIDS*. Oct 23 2010;24(16):2489-2497.
40. Sturmer M, Doerr HW, Berger A, Gute P. Is transmission of HIV-1 in non-viraemic serodiscordant couples possible? *Antivir Ther*. 2008;13(5):729-732.
41. Crepaz N, Hart TA, Marks G. Highly active antiretroviral therapy and sexual risk behavior: a meta-analytic review. *JAMA*. Jul 14 2004;292(2):224-236.
42. Rice E, Batterham P, Rotheram-Borus MJ. Unprotected sex among youth living with HIV before and after the advent of highly active antiretroviral therapy. *Perspect Sex Reprod Health*. Sep 2006;38(3):162-167.



## Conclusion (Last updated January 28, 2016; last reviewed January 28, 2016)

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The Panel has carefully reviewed results from clinical HIV therapy trials and considered how they affect appropriate care guidelines. HIV care is complex and rapidly evolving. Where possible, the Panel has based recommendations on the best evidence from prospective trials with defined endpoints. Absent such evidence, the Panel has attempted to base recommendations on reasonable options for HIV care.

HIV care requires partnerships and open communication. Guidelines are only a starting point for medical decision making involving informed providers and patients. Although guidelines can identify some parameters of high-quality care, they cannot substitute for sound clinical judgment.

As further research is conducted and reported, these guidelines will be modified. The Panel anticipates continued progress in refining ART regimens and strategies. The Panel hopes these guidelines are useful and is committed to their continued revision and improvement.

## Appendix A: Key to Acronyms (Last updated April 8, 2015; last reviewed April 8, 2015)

### ***Drug Name Abbreviations***

<b>Abbreviation</b>	<b>Full Name</b>
3TC	lamivudine
ABC	abacavir
APV	amprenavir
ATV	atazanavir
ATV/c	atazanavir/cobicistat
ATV/r	atazanavir/ritonavir
COBI or c	cobicistat
d4T	stavudine
ddC	zalcitabine
ddI	didanosine
DLV	delavirdine
DRV	darunavir
DRV/c	darunavir/cobicistat
DRV/r	darunavir/ritonavir
DTG	dolutegravir
EFV	efavirenz
EFV/c/TDF/FTC	efavirenz/cobicistat/tenofovir disoproxil fumarate/emtricitabine
ETR	etravirine
EVG	elvitegravir
EVG/c	elvitegravir/cobicistat
EVG/c/TAF/FTC	elvitegravir/cobicistat/tenofovir alafenamide/emtricitabine
EVG/c/TDF/FTC	elvitegravir/cobicistat/tenofovir disoproxil fumarate/emtricitabine
EVG/r	elvitegravir/ritonavir
FPV	fosamprenavir
FPV/r	fosamprenavir/ritonavir
FTC	emtricitabine
IDV	indinavir
LPV	lopinavir
LPV/r	lopinavir/ritonavir
MVC	maraviroc
NFV	nelfinavir
NVP	nevirapine
PI/c	cobicistat-boosted protease inhibitor
PI/r	ritonavir-boosted protease inhibitor
RAL	raltegravir
RPV	rilpivirine

RTV	ritonavir
SQV	saquinavir
SQV/r	saquinavir/ritonavir
TDF	tenofovir disoproxil fumarate
TPV	tipranavir
TPV/r	tipranavir/ritonavir
ZDV	zidovudine

## ***General Terms***

<b>Abbreviation</b>	<b>Definition</b>
17-BMP	beclomethasone 17-monopropionate
Al	aluminum
ART	antiretroviral therapy
ARV	antiretroviral
AUC	area under the curve
AWP	average wholesale price
BID	twice daily
BMD	bone mineral density
Ca	calcium
CaCO <sub>3</sub>	calcium carbonate
cap	capsule
CCB	calcium channel blockers
CD4	CD4 T lymphocyte
C <sub>max</sub>	maximum plasma concentration
C <sub>min</sub>	minimum plasma concentration
CNS	central nervous system
CPK	creatine phosphokinase
Cr	creatinine
CrCl	creatinine clearance
CVD	cardiovascular disease
CYP	cytochrome P
DAAs	direct-acting antivirals
DHA	dihydroartemisinin
DMPA	depot medroxyprogesterone acetate
DSMB	Data Safety Monitoring Board
EC	enteric coated
ECG	electrocardiogram
EI	entry inhibitor
FDA	Food and Drug Administration

Fe	iron
GAZT	azidothymidine glucuronide
GI	gastrointestinal
HBV	hepatitis B virus
HCV	hepatitis C virus
HDL	high-density lipoprotein
HLA	human leukocyte antigen
HMG-CoA	hydroxy-methylglutaryl-coenzyme A
HSR	hypersensitivity reaction
INR	international normalized ratio
INSTI	integrase strand transfer inhibitor
LDL	low-density lipoprotein
MAC	<i>Mycobacterium avium</i> complex
MATE	multidrug and toxin extrusion transporter
Mg	magnesium
MI	myocardial infarction
N/A	Not Applicable
NNRTI	non-nucleoside reverse transcriptase inhibitor
NRTI	nucleoside reverse transcriptase inhibitor
OCT2	organic cation transporter 2
OH-itraconazole	active metabolite of itraconazole
PAH	pulmonary arterial hypertension
PDE5	phosphodiesterase type 5
PI	protease inhibitor
PPI	proton pump inhibitor
PK	pharmacokinetic
QTc	QT corrected for heart rate
SCr	serum creatinine
soln	solution
SSRI	selective serotonin reuptake inhibitor
susp	suspension
tab	tablet
TB	tuberculosis
TCA	tricyclic anti-depressant
TG	triglyceride
TID	three times a day
UGT1A1	uridine diphosphate glucuronosyltransferase
VPA	valproic acid
WHO	World Health Organization

XR

extended release

Zn

zinc

**Appendix B, Table 1. Characteristics of Nucleoside Reverse Transcriptase Inhibitors (Last updated April 8, 2015; last reviewed April 8, 2015) (page 1 of 5)**

Generic Name (Abbreviation) Trade Name	Formulations	Dosing Recommendations <sup>a</sup>	Elimination	Serum/ Intracellular Half-Lives	Adverse Events <sup>b</sup>
<b>Abacavir</b> (ABC) <i>Ziagen</i>  <b>Note:</b> Generic available in tablet formulation  <b>Also available as a component of fixed-dose combinations.</b>	<b>Ziagen:</b> <ul style="list-style-type: none"> <li>• 300 mg tablet</li> <li>• 20 mg/mL oral solution</li> </ul>	<b>Ziagen:</b> <ul style="list-style-type: none"> <li>• 300 mg BID, or</li> <li>• 600 mg once daily</li> <li>• Take without regard to meals.</li> </ul>	Metabolized by alcohol dehydrogenase and glucuronyl transferase  Renal excretion of metabolites: 82%  Dosage adjustment for ABC is recommended in patients with hepatic insufficiency (see <a href="#">Appendix B, Table 7</a> ).	1.5 hours/ 12–26 hours	<ul style="list-style-type: none"> <li>• HSRs: Patients who test positive for HLA-B*5701 are at highest risk. HLA screening should be done before initiation of ABC.</li> <li>• For patients with history of HSR, re-challenge is not recommended.</li> <li>• Symptoms of HSR may include fever, rash, nausea, vomiting, diarrhea, abdominal pain, malaise, fatigue, or respiratory symptoms such as sore throat, cough, or shortness of breath.</li> <li>• Some cohort studies suggest increased risk of MI with recent or current use of ABC, but this risk is not substantiated in other studies.</li> </ul>
<b>Trizivir</b> (ABC/ZDV/3TC)  <b>Note:</b> Generic available	<b>Trizivir:</b> <ul style="list-style-type: none"> <li>• (ABC 300 mg plus ZDV 300 mg plus 3TC 150 mg) tablet</li> </ul>	<b>Trizivir:</b> <ul style="list-style-type: none"> <li>• 1 tablet BID</li> </ul>			
<b>Epzicom</b> (ABC/3TC)	<b>Epzicom:</b> <ul style="list-style-type: none"> <li>• (ABC 600 mg plus 3TC 300 mg) tablet</li> </ul>	<b>Epzicom:</b> <ul style="list-style-type: none"> <li>• 1 tablet once daily</li> </ul>			
<b>Triumeq</b> (ABC/3TC/DTG)	<b>Triumeq:</b> <ul style="list-style-type: none"> <li>• (ABC 600 mg plus 3TC 300 mg plus DTG 50 mg) tablet</li> </ul>	<b>Triumeq:</b> <ul style="list-style-type: none"> <li>• 1 tablet once daily</li> </ul>			
<b>Didanosine</b> (ddl) <i>Videx</i> <i>Videx EC</i>  <b>Note:</b> Generic available; dose same as Videx or Videx EC	<b>Videx EC:</b> <ul style="list-style-type: none"> <li>• 125, 200, 250, and 400 mg capsules</li> </ul> <b>Videx:</b> <ul style="list-style-type: none"> <li>• 10 mg/mL oral solution</li> </ul>	<b>Body Weight ≥60 kg:</b> <ul style="list-style-type: none"> <li>• 400 mg once daily</li> </ul> <b>With TDF:</b> <ul style="list-style-type: none"> <li>• 250 mg once daily</li> </ul> <b>Body Weight &lt;60 kg:</b> <ul style="list-style-type: none"> <li>• 250 mg once daily</li> </ul> <b>With TDF:</b> <ul style="list-style-type: none"> <li>• 200 mg once daily</li> </ul> Take 1/2 hour before or 2 hours after a meal.  <b>Note:</b> Preferred dosing with oral solution is BID (total daily dose divided into 2 doses).	Renal excretion: 50%  Dosage adjustment in patients with renal insufficiency is recommended (see <a href="#">Appendix B, Table 7</a> ).	1.5 hours/ >20 hours	<ul style="list-style-type: none"> <li>• Pancreatitis</li> <li>• Peripheral neuropathy</li> <li>• Retinal changes, optic neuritis</li> <li>• Lactic acidosis with hepatic steatosis with or without pancreatitis (rare but potentially life-threatening toxicity)</li> <li>• Nausea, vomiting</li> <li>• Potential association with non-cirrhotic portal hypertension; in some cases, patients presented with esophageal varices</li> <li>• One cohort study suggested increased risk of MI with recent or current use of ddl, but this risk is not substantiated in other studies.</li> <li>• Insulin resistance/diabetes mellitus</li> </ul>



**Appendix B, Table 1. Characteristics of Nucleoside Reverse Transcriptase Inhibitors (Last updated April 8, 2015; last reviewed April 8, 2015) (page 2 of 5)**

Generic Name (Abbreviation) Trade Name	Formulations	Dosing Recommendations <sup>a</sup>	Elimination	Serum/ Intracellular Half-Lives	Adverse Events <sup>b</sup>
<b>Emtricitabine</b> (FTC) <i>Emtriva</i>  <b>Also available as a component of fixed-dose combinations.</b>	<u>Emtriva:</u> • 200 mg hard gelatin capsule  • 10 mg/mL oral solution	<u>Emtriva</u>  <u>Capsule:</u> • 200 mg once daily  <u>Oral Solution:</u> • 240 mg (24 mL) once daily  Take without regard to meals.	Renal excretion: 86%  Dosage adjustment in patients with renal insufficiency is recommended (see <a href="#">Appendix B, Table 7</a> ).	10 hours/ >20 hours	• Minimal toxicity • Hyperpigmentation/skin discoloration • Severe acute exacerbation of hepatitis may occur in HBV- coinfected patients who discontinue FTC.
<i>Atripla</i> (FTC/EFV/TDF)	<u>Atripla:</u> • (FTC 200 mg plus EFV 600 mg plus TDF 300 mg) tablet	<u>Atripla:</u> • 1 tablet at or before bedtime • Take on an empty stomach to reduce side effects.			
<i>Complera</i> (FTC/RPV/TDF)	<u>Complera:</u> • (FTC 200 mg plus RPV 25 mg plus TDF 300 mg) tablet	<u>Complera:</u> • 1 tablet once daily with a meal			
<i>Stribild</i> (FTC/EVG/c/ TDF)	<u>Stribild:</u> • (FTC 200 mg plus EVG 150 mg plus COBI 150 mg plus TDF 300 mg) tablet	<u>Stribild:</u> • 1 tablet once daily with food			
<i>Truvada</i> (FTC/TDF)	<u>Truvada:</u> • (FTC 200 mg plus TDF 300 mg) tablet	<u>Truvada:</u> • 1 tablet once daily			

**Appendix B, Table 1. Characteristics of Nucleoside Reverse Transcriptase Inhibitors (Last updated April 8, 2015; last reviewed April 8, 2015) (page 3 of 5)**

Generic Name (Abbreviation) Trade Name	Formulations	Dosing Recommendations <sup>a</sup>	Elimination	Serum/ Intracellular Half-Lives	Adverse Events <sup>b</sup>
<b>Lamivudine</b> (3TC) <i>Epivir</i>  <b>Note:</b> Generic available  <b>Also available as a component of fixed-dose combinations.</b>	<b>Epivir:</b> <ul style="list-style-type: none"> <li>• 150 and 300 mg tablets</li> <li>• 10 mg/mL oral solution</li> </ul>	<b>Epivir:</b> <ul style="list-style-type: none"> <li>• 150 mg BID, or</li> <li>• 300 mg once daily</li> <li>• Take without regard to meals.</li> </ul>	Renal excretion: 70%  Dosage adjustment in patients with renal insufficiency is recommended (see <a href="#">Appendix B, Table 7</a> ).	5–7 hours/ 18–22 hours	<ul style="list-style-type: none"> <li>• Minimal toxicity</li> <li>• Severe acute exacerbation of hepatitis may occur in HBV-coinfected patients who discontinue 3TC.</li> </ul>
<b>Combivir</b> (3TC/ZDV)  <b>Note:</b> Generic available	<b>Combivir:</b> <ul style="list-style-type: none"> <li>• (3TC 150 mg plus ZDV 300 mg) tablet</li> </ul>	<b>Combivir:</b> <ul style="list-style-type: none"> <li>• 1 tablet BID</li> </ul>			
<b>Epzicom</b> (3TC/ABC)	<b>Epzicom:</b> <ul style="list-style-type: none"> <li>• (3TC 300 mg plus ABC 600 mg) tablet</li> </ul>	<b>Epzicom:</b> <ul style="list-style-type: none"> <li>• 1 tablet once daily</li> </ul>			
<b>Trizivir</b> (3TC/ZDV/ABC)  <b>Note:</b> Generic available	<b>Trizivir:</b> <ul style="list-style-type: none"> <li>• (3TC 150 mg plus ZDV 300 mg plus ABC 300 mg) tablet</li> </ul>	<b>Trizivir:</b> <ul style="list-style-type: none"> <li>• 1 tablet BID</li> </ul>			
<b>Triumeq</b> (3TC/ABC/DTG)	<b>Triumeq:</b> <ul style="list-style-type: none"> <li>• (3TC 300 mg plus ABC 600 mg plus DTG 50 mg) tablet</li> </ul>	<b>Triumeq:</b> <ul style="list-style-type: none"> <li>• 1 tablet once daily</li> </ul>			
<b>Stavudine</b> (d4T) <i>Zerit</i>  <b>Note:</b> Generic available	<b>Zerit:</b> <ul style="list-style-type: none"> <li>• 15, 20, 30, and 40 mg capsules</li> <li>• 1 mg/mL oral solution</li> </ul>	<b>Body Weight <math>\geq</math>60 kg:</b> <ul style="list-style-type: none"> <li>• 40 mg BID</li> </ul> <b>Body Weight &lt;60 kg:</b> <ul style="list-style-type: none"> <li>• 30 mg BID</li> </ul> Take without regard to meals.  <b>Note:</b> WHO recommends 30 mg BID dosing regardless of body weight.	Renal excretion: 50%  Dosage adjustment in patients with renal insufficiency is recommended (see <a href="#">Appendix B, Table 7</a> ).	1 hour/ 7.5 hours	<ul style="list-style-type: none"> <li>• Peripheral neuropathy</li> <li>• Lipoatrophy</li> <li>• Pancreatitis</li> <li>• Lactic acidosis/severe hepatomegaly with hepatic steatosis (rare but potentially life-threatening toxicity)</li> <li>• Hyperlipidemia</li> <li>• Insulin resistance/diabetes mellitus</li> <li>• Rapidly progressive ascending neuromuscular weakness (rare)</li> </ul>

**Appendix B, Table 1. Characteristics of Nucleoside Reverse Transcriptase Inhibitors (Last updated April 8, 2015; last reviewed April 8, 2015) (page 4 of 5)**

Generic Name (Abbreviation) Trade Name	Formulations	Dosing Recommendations <sup>a</sup>	Elimination	Serum/ Intracellular Half-Lives	Adverse Events <sup>b</sup>
<b>Tenofovir Disoproxil Fumarate (TDF)</b> <i>Viread</i> <b>Also available as a component of fixed-dose combinations.</b>	<u>Viread:</u> <ul style="list-style-type: none"> <li>• 150, 200, 250, and 300 mg tablets</li> <li>• 40 mg/g oral powder</li> </ul>	<u>Viread:</u> <ul style="list-style-type: none"> <li>• 300 mg once daily, or</li> <li>• 7.5 level scoops once daily (dosing scoop dispensed with each prescription; one level scoop contains 1 g of oral powder).</li> <li>• Take without regard to meals.</li> </ul> <p>Mix oral powder with 2–4 ounces of a soft food that does not require chewing (e.g., applesauce, yogurt). <b><u>Do not mix oral powder with liquid.</u></b></p>	<p>Renal excretion is primary route of elimination.</p> <p>Dosage adjustment in patients with renal insufficiency is recommended (see <a href="#">Appendix B, Table 7</a>).</p>	17 hours/ >60 hours	<ul style="list-style-type: none"> <li>• Renal insufficiency, Fanconi syndrome, proximal renal tubulopathy</li> <li>• Osteomalacia, decrease in bone mineral density</li> <li>• Severe acute exacerbation of hepatitis may occur in HBV-coinfected patients who discontinue TDF.</li> <li>• Asthenia, headache, diarrhea, nausea, vomiting, and flatulence</li> </ul>
<i>Atripla</i> TDF/EFV/FTC	<u>Atripla:</u> <ul style="list-style-type: none"> <li>• (TDF 300 mg plus EFV 600 mg plus FTC 200 mg) tablet</li> </ul>	<u>Atripla:</u> <ul style="list-style-type: none"> <li>• 1 tablet at or before bedtime</li> <li>• Take on an empty stomach to reduce side effects.</li> </ul>			
<i>Complera</i> TDF/RPV/FTC	<u>Complera:</u> <ul style="list-style-type: none"> <li>• (TDF 300 mg plus RPV 25 mg plus FTC 200 mg) tablet</li> </ul>	<u>Complera:</u> <ul style="list-style-type: none"> <li>• 1 tablet once daily</li> <li>• Take with a meal</li> </ul>			
<i>Stribild</i> (TDF/EVG/c/FTC)	<u>Stribild:</u> <ul style="list-style-type: none"> <li>• (TDF 300 mg plus EVG 150 mg plus COBI 150 mg plus FTC 200 mg) tablet</li> </ul>	<u>Stribild:</u> <ul style="list-style-type: none"> <li>• 1 tablet once daily</li> <li>• Take with food.</li> </ul>			
<i>Truvada</i> (TDF/FTC)	<u>Truvada:</u> <ul style="list-style-type: none"> <li>• (TDF 300 mg plus FTC 200 mg) tablet</li> </ul>	<u>Truvada:</u> <ul style="list-style-type: none"> <li>• 1 tablet once daily</li> <li>• Take without regard to meals.</li> </ul>			

**Appendix B, Table 1. Characteristics of Nucleoside Reverse Transcriptase Inhibitors (Last updated April 8, 2015; last reviewed April 8, 2015) (page 5 of 5)**

Generic Name (Abbreviation) Trade Name	Formulations	Dosing Recommendations <sup>a</sup>	Elimination	Serum/ Intracellular Half-Lives	Adverse Events <sup>b</sup>
<b>Zidovudine</b> (ZDV) <i>Retrovir</i>  <b>Note:</b> Generic available  <b>Also available as a component of fixed-dose combinations.</b>	<b>Retrovir:</b> <ul style="list-style-type: none"> <li>• 100 mg capsule</li> <li>• 300 mg tablet (only available as generic)</li> <li>• 10 mg/mL intravenous solution</li> <li>• 10 mg/mL oral solution</li> </ul>	<b>Retrovir:</b> <ul style="list-style-type: none"> <li>• 300 mg BID, or</li> <li>• 200 mg TID</li> <li>• Take without regard to meals.</li> </ul>	Metabolized to GAZT  Renal excretion of GAZT  Dosage adjustment in patients with renal insufficiency is recommended (see <a href="#">Appendix B, Table 7</a> ).	1.1 hours/ 7 hours	<ul style="list-style-type: none"> <li>• Bone marrow suppression: macrocytic anemia or neutropenia</li> <li>• Nausea, vomiting, headache, insomnia, asthenia</li> <li>• Nail pigmentation</li> <li>• Lactic acidosis/severe hepatomegaly with hepatic steatosis (rare but potentially life-threatening toxicity)</li> <li>• Hyperlipidemia</li> <li>• Insulin resistance/diabetes mellitus</li> <li>• Lipoatrophy</li> <li>• Myopathy</li> </ul>
<b>Combivir</b> (ZDV/3TC)  <b>Note:</b> Generic available	<b>Combivir:</b> <ul style="list-style-type: none"> <li>• (ZDV 300 mg plus 3TC 150 mg) tablet</li> </ul>	<b>Combivir:</b> <ul style="list-style-type: none"> <li>• 1 tablet BID</li> <li>• Take without regard to meals.</li> </ul>			
<b>Trizivir</b> (ZDV/3TC/ABC)  <b>Note:</b> Generic available	<b>Trizivir:</b> <ul style="list-style-type: none"> <li>• (ZDV 300 mg plus 3TC 150 mg plus ABC 300 mg) tablet</li> </ul>	<b>Trizivir:</b> <ul style="list-style-type: none"> <li>• 1 tablet BID</li> <li>• Take without regard to meals.</li> </ul>			

<sup>a</sup> For dosage adjustment in renal or hepatic insufficiency, see [Appendix B, Table 7](#).

<sup>b</sup> Also see [Table 14](#).

**Key to Acronyms:** 3TC = lamivudine; ABC = abacavir; BID = twice daily; c, COBI = cobicistat; d4T = stavudine; ddl = didanosine; DTG = dolutegravir; EC = enteric coated; EFV = efavirenz; EVG = elvitegravir; FTC = emtricitabine; GAZT = azidothymidine glucuronide; HBV = hepatitis B virus; HLA = human leukocyte antigen; HSR = hypersensitivity reaction; MI = myocardial infarction; RPV = rilpivirine; TDF = tenofovir disoproxil fumarate; TID = three times a day; WHO = World Health Organization; ZDV = zidovudine

**Appendix B, Table 2. Characteristics of Non-Nucleoside Reverse Transcriptase Inhibitors (Last updated April 8, 2014; last reviewed April 8, 2015) (page 1 of 2)**

**Note:** DLV is not included in this table. Please refer to the DLV FDA package insert for related information.

Generic Name (Abbreviation) Trade Name	Formulations	Dosing Recommendations <sup>a</sup>	Elimination/ Metabolic Pathway	Serum/ Half-Life	Adverse Events <sup>b</sup>
<b>Efavirenz</b> (EFV) <i>Sustiva</i>  <b>Also available as a component of fixed-dose combination.</b>	<u>Sustiva:</u> • 50 and 200 mg capsules • 600 mg tablet	<u>Sustiva:</u> • 600 mg once daily, at or before bedtime • Take on an empty stomach to reduce side effects.	Metabolized by CYPs 2B6 (primary), 3A4, and 2A6  CYP3A4 mixed inducer/inhibitor (more an inducer than an inhibitor)	40–55 hours	• Rash <sup>c</sup> • Neuropsychiatric symptoms <sup>d</sup> • Increased transaminase levels • Hyperlipidemia • False-positive results with some cannabinoid and benzodiazepine screening assays reported. • Teratogenic in non-human primates and potentially teratogenic during the first trimester of pregnancy in humans
<i>Atripla</i> (EFV/TDF/FTC)	<u>Atripla:</u> • (EFV 600 mg plus FTC 200 mg plus TDF 300 mg) tablet	<u>Atripla:</u> • 1 tablet once daily, at or before bedtime	CYP2C9 and 2C19 inhibitor; 2B6 inducer		
<b>Etravirine</b> (ETR) <i>Intelligence</i>	• 25, 100, and 200 mg tablets	200 mg BID  Take following a meal.	CYP3A4, 2C9, and 2C19 substrate  3A4 inducer; 2C9 and 2C19 inhibitor	41 hours	• Rash, including Stevens-Johnson syndrome <sup>c</sup> • HSRs, characterized by rash, constitutional findings, and sometimes organ dysfunction (including hepatic failure) have been reported. • Nausea
<b>Nevirapine</b> (NVP) <i>Viramune</i> or <i>Viramine XR</i>  Generic available for 200 mg tablets and oral suspension	• 200 mg tablet • 400 mg XR tablet • 50 mg/5 mL oral suspension	200 mg once daily for 14 days (lead-in period); thereafter, 200 mg BID, or 400 mg (Viramune XR tablet) once daily  Take without regard to meals.  Repeat lead-in period if therapy is discontinued for >7 days.  In patients who develop mild-to-moderate rash without constitutional symptoms, continue lead-in period until rash resolves but not longer than 28 days total.	CYP450 substrate, inducer of 3A4 and 2B6; 80% excreted in urine (glucuronidated metabolites, <5% unchanged); 10% in feces	25–30 hours	• Rash, including Stevens-Johnson syndrome <sup>c</sup> • Symptomatic hepatitis, including fatal hepatic necrosis, has been reported: • Rash reported in approximately 50% of cases. • Occurs at significantly higher frequency in ARV-naïve female patients with pre-NVP CD4 counts >250 cells/mm <sup>3</sup> and in ARV-naïve male patients with pre-NVP CD4 counts >400 cells/mm <sup>3</sup> . NVP should not be initiated in these patients unless the benefit clearly outweighs the risk.

**Appendix B, Table 2. Characteristics of Non-Nucleoside Reverse Transcriptase Inhibitors (Last updated April 8, 2014; last reviewed April 8, 2015) (page 2 of 2)**

**Note:** DLV is not included in this table. Please refer to the DLV FDA package insert for related information.

Generic Name (Abbreviation) Trade Name	Formulations	Dosing Recommendations <sup>a</sup>	Elimination/ Metabolic Pathway	Serum/ Half-Life	Adverse Events <sup>b</sup>
<b>Rilpivirine</b> (RPV) <i>Edurant</i>  <b>Also available as a component of fixed-dose combination.</b>	<u>Edurant:</u> • 25 mg tablet	<u>Edurant:</u> • 25 mg once daily • Take with a meal.	CYP3A4 substrate	50 hours	• Rash <sup>c</sup> • Depression, insomnia, headache • Hepatotoxicity
<i>Complera</i> (RPV/TDF/FTC)	<u>Complera:</u> • (RPV 25 mg plus TDF 300 mg plus FTC 200 mg) tablet	<u>Complera:</u> • 1 tablet once daily • Take with a meal.			

<sup>a</sup> For dosage adjustment in renal or hepatic insufficiency, see [Appendix B, Table 7](#).

<sup>b</sup> Also see [Table 14](#).

<sup>c</sup> Rare cases of Stevens-Johnson syndrome have been reported with most NNRTIs; the highest incidence of rash was seen with NVP.

<sup>d</sup> Adverse events can include dizziness, somnolence, insomnia, abnormal dreams, depression, suicidality (suicide, suicide attempt or ideation), confusion, abnormal thinking, impaired concentration, amnesia, agitation, depersonalization, hallucinations, and euphoria. Approximately 50% of patients receiving EFV may experience any of these symptoms. Symptoms usually subside spontaneously after 2 to 4 weeks but may necessitate discontinuation of EFV in a small percentage of patients.

**Key to Abbreviations:** ARV = antiretroviral; BID = twice daily; CD4 = CD4 T lymphocyte; CYP = cytochrome P; DLV = delavirdine; EFV = efavirenz; ETR = etravirine; FDA = Food and Drug Administration; FTC = emtricitabine; HSR = hypersensitivity reaction; NNRTI = non-nucleoside reverse transcriptase inhibitor; NVP = nevirapine; RPV = rilpivirine; TDF = tenofovir disoproxil fumarate; XR = extended release



**Appendix B, Table 3. Characteristics of Protease Inhibitors (Last updated April 8, 2015; last reviewed April 8, 2015) (page 1 of 4)**

Generic Name (Abbreviation) Trade Name	Formulations	Dosing Recommendations <sup>a</sup>	Elimination/ Metabolic Pathway	Serum Half-Life	Storage	Adverse Events <sup>b</sup>
<b>Atazanavir</b> (ATV) <i>Reyataz</i>  <b>Also available as a component of fixed-dose combination.</b>	<b>Reyataz:</b> <ul style="list-style-type: none"> <li>• 100, 150, 200, and 300 mg capsules</li> <li>• 50 mg single packet oral powder</li> </ul>	<b>In ARV-Naive Patients:</b> <ul style="list-style-type: none"> <li>• (ATV 300 mg plus RTV 100 mg) once daily; or</li> <li>• ATV 400 mg once daily</li> </ul> <b>With TDF or in ARV-Experienced Patients:</b> <ul style="list-style-type: none"> <li>• (ATV 300 mg plus RTV 100 mg) once daily</li> </ul> <b>With EFV in ARV-Naive Patients:</b> <ul style="list-style-type: none"> <li>• (ATV 400 mg plus RTV 100 mg) once daily</li> </ul> <p>Take with food.</p> <p>For recommendations on dosing with H2 antagonists and PPIs, refer to <a href="#">Table 19a</a>.</p>	CYP3A4 inhibitor and substrate; weak CYP2C8 inhibitor; UGT1A1 inhibitor  Dosage adjustment in patients with hepatic insufficiency is recommended (see <a href="#">Appendix B, Table 7</a> ).	7 hours	Room temperature (up to 25° C or 77° F)	<ul style="list-style-type: none"> <li>• Indirect hyperbilirubinemia</li> <li>• PR interval prolongation: First degree symptomatic AV block reported. Use with caution in patients with underlying conduction defects or on concomitant medications that can cause PR prolongation.</li> <li>• Hyperglycemia</li> <li>• Fat maldistribution</li> <li>• Cholelithiasis</li> <li>• Nephrolithiasis</li> <li>• Renal insufficiency</li> <li>• Serum transaminase elevations</li> <li>• Hyperlipidemia (especially with RTV boosting)</li> <li>• Skin rash</li> <li>• Increase in serum creatinine (with COBI)</li> </ul>
<b>Evotaz</b> (ATV/c)	<b>Evotaz:</b> <ul style="list-style-type: none"> <li>• (ATV 300 mg plus COBI 150 mg) tablet</li> </ul>	<b>Evotaz:</b> <ul style="list-style-type: none"> <li>• 1 tablet once daily</li> <li>• Take with food.</li> </ul> <b>With TDF:</b> <ul style="list-style-type: none"> <li>• <b>Not recommended</b> for patients with baseline CrCl &lt; 70 mL/min (see <a href="#">Appendix B, Table 7</a> for the equation for calculating CrCl).</li> </ul>	ATV: as above  COBI: substrate of CYP3A, CYP2D6 (minor); CYP3A inhibitor			
<b>Darunavir</b> (DRV) <i>Prezista</i>  <b>Also available as a component of fixed-dose combination.</b>	<ul style="list-style-type: none"> <li>• 75, 150, 600, and 800 mg tablets</li> <li>• 100 mg/mL oral suspension</li> </ul>	<b>In ARV-Naive Patients or ARV-Experienced Patients with No DRV Mutations:</b> <ul style="list-style-type: none"> <li>• (DRV 800 mg plus RTV 100 mg) once daily</li> </ul> <b>In ARV-Experienced Patients with One or More DRV Resistance Mutations:</b> <ul style="list-style-type: none"> <li>• (DRV 600 mg plus RTV 100 mg) BID</li> </ul> <p>Unboosted DRV is <b>not</b> recommended.</p> <p>Take with food.</p>	CYP3A4 inhibitor and substrate  CYP2C9 inducer	15 hours (when combined with RTV)	Room temperature (up to 25° C or 77° F)	<ul style="list-style-type: none"> <li>• Skin rash (10%): DRV has a sulfonamide moiety; Stevens-Johnson syndrome, toxic epidermal necrolysis, acute generalized exanthematous pustulosis, and erythema multiforme have been reported.</li> <li>• Hepatotoxicity</li> <li>• Diarrhea, nausea</li> <li>• Headache</li> <li>• Hyperlipidemia</li> <li>• Serum transaminase elevation</li> <li>• Hyperglycemia</li> <li>• Fat maldistribution</li> <li>• Increase in serum creatinine (with COBI)</li> </ul>
<b>Prezcobix</b> (DRV/c)	<b>Prezcobix:</b> <ul style="list-style-type: none"> <li>• (DRV 800 mg plus COBI 150 mg) tablet</li> </ul>	<b>Prezcobix:</b> <ul style="list-style-type: none"> <li>• 1 tablet once daily</li> <li>• Take with food.</li> </ul> <p><b>Not recommended</b> for patients with one or more DRV resistance-associated mutations.</p> <b>With TDF:</b> <ul style="list-style-type: none"> <li>• <b>Not recommended</b> for patients with baseline CrCl &lt; 70 mL/min (see <a href="#">Appendix B, Table 7</a> for the equation for calculating CrCl).</li> </ul>	DRV: As above  COBI: substrate of CYP3A, CYP2D6 (minor); CYP3A inhibitor			

**Appendix B, Table 3. Characteristics of Protease Inhibitors (Last updated April 8, 2015; last reviewed April 8, 2015) (page 2 of 4)**

Generic Name (Abbreviation) Trade Name	Formulations	Dosing Recommendations <sup>a</sup>	Elimination/ Metabolic Pathway	Serum Half-Life	Storage	Adverse Events <sup>b</sup>
<b>Fosamprenavir</b> (FPV) <i>Lexiva</i> (a prodrug of APV)	<ul style="list-style-type: none"> <li>• 700 mg tablet</li> <li>• 50 mg/mL oral suspension</li> </ul>	<p><u>In ARV-Naive Patients:</u></p> <ul style="list-style-type: none"> <li>• FPV 1400 mg BID, or</li> <li>• (FPV 1400 mg plus RTV 100–200 mg) once daily, or</li> <li>• (FPV 700 mg plus RTV 100 mg) BID</li> </ul> <p><u>In PI-Experienced Patients (Once-Daily Dosing Not Recommended):</u></p> <ul style="list-style-type: none"> <li>• (FPV 700 mg plus RTV 100 mg) BID</li> </ul> <p><u>With EFV:</u></p> <ul style="list-style-type: none"> <li>• (FPV 700 mg plus RTV 100 mg) BID, or</li> <li>• (FPV 1400 mg plus RTV 300 mg) once daily</li> </ul> <p><u>Tablet:</u></p> <ul style="list-style-type: none"> <li>• Without RTV tablet: Take without regard to meals.</li> <li>• With RTV tablet: Take with meals.</li> </ul> <p><u>Oral Suspension:</u></p> <ul style="list-style-type: none"> <li>• Take without food.</li> </ul>	<p>APV is a CYP3A4 substrate, inhibitor, and inducer.</p> <p>Dosage adjustment in patients with hepatic insufficiency is recommended (see <a href="#">Appendix B, Table 7</a>).</p>	7.7 hours (APV)	Room temperature (up to 25° C or 77° F)	<ul style="list-style-type: none"> <li>• Skin rash (12% to 19%): FPV has a sulfonamide moiety.</li> <li>• Diarrhea, nausea, vomiting</li> <li>• Headache</li> <li>• Hyperlipidemia</li> <li>• Serum transaminase elevation</li> <li>• Hyperglycemia</li> <li>• Fat maldistribution</li> <li>• Possible increased bleeding episodes in patients with hemophilia</li> <li>• Nephrolithiasis</li> </ul>
<b>Indinavir</b> (IDV) <i>Crixivan</i>	100, 200, and 400 mg capsules	<ul style="list-style-type: none"> <li>• 800 mg every 8 hours</li> <li>• Take 1 hour before or 2 hours after meals; may take with skim milk or a low-fat meal.</li> </ul> <p><u>With RTV:</u></p> <ul style="list-style-type: none"> <li>• (IDV 800 mg plus RTV 100–200 mg) BID</li> <li>• Take without regard to meals.</li> </ul>	<p>CYP3A4 inhibitor and substrate</p> <p>Dosage adjustment in patients with hepatic insufficiency is recommended (see <a href="#">Appendix B, Table 7</a>).</p>	1.5–2 hours	<p>Room temperature (15° to 30° C or 59° to 86° F)</p> <p>Protect from moisture.</p>	<ul style="list-style-type: none"> <li>• Nephrolithiasis</li> <li>• GI intolerance, nausea</li> <li>• Hepatitis</li> <li>• Indirect hyperbilirubinemia</li> <li>• Hyperlipidemia</li> <li>• Headache, asthenia, blurred vision, dizziness, rash, metallic taste, thrombocytopenia, alopecia, and hemolytic anemia</li> <li>• Hyperglycemia</li> <li>• Fat maldistribution</li> <li>• Possible increased bleeding episodes in patients with hemophilia</li> </ul>

**Appendix B, Table 3. Characteristics of Protease Inhibitors (Last updated April 8, 2015; last reviewed April 8, 2015) (page 3 of 4)**

Generic Name (Abbreviation) Trade Name	Formulations	Dosing Recommendations <sup>a</sup>	Elimination/ Metabolic Pathway	Serum Half- Life	Storage	Adverse Events <sup>b</sup>
<b>Lopinavir/ Ritonavir</b> (LPV/r) <i>Kaletra</i>	<p><u>Tablets:</u></p> <ul style="list-style-type: none"> <li>• (LPV 200 mg plus RTV 50 mg), or</li> <li>• (LPV 100 mg plus RTV 25 mg)</li> </ul> <p><u>Oral Solution:</u></p> <ul style="list-style-type: none"> <li>• Each 5 mL contains (LPV 400 mg plus RTV 100 mg).</li> <li>• Oral solution contains 42% alcohol.</li> </ul>	<ul style="list-style-type: none"> <li>• (LPV 400 mg plus RTV 100 mg) BID, or</li> <li>• (LPV 800 mg plus RTV 200 mg) once daily</li> </ul> <p>Once-daily dosing is not recommended for patients with <math>\geq 3</math> LPV-associated mutations, pregnant women, or patients receiving EFV, NVP, FPV, NFV, carbamazepine, phenytoin, or phenobarbital.</p> <p><u>With EFV or NVP (PI-Naive or PI-Experienced Patients):</u></p> <ul style="list-style-type: none"> <li>• LPV/r 500 mg/125 mg tablets BID (use a combination of 2 LPV/r 200 mg/50 mg tablets plus 1 LPV/r 100 mg/25 mg tablet to make a total dose of LPV/r 500 mg/125 mg), or</li> <li>• LPV/r 533 mg/133 mg oral solution BID</li> </ul> <p><u>Tablet:</u></p> <ul style="list-style-type: none"> <li>• Take without regard to meals.</li> </ul> <p><u>Oral Solution:</u></p> <ul style="list-style-type: none"> <li>• Take with food.</li> </ul>	CYP3A4 inhibitor and substrate	5–6 hours	<p>Oral tablet is stable at room temperature.</p> <p>Oral solution is stable at 2° to 8° C (36° to 46° F) until date on label and is stable for up to 2 months when stored at room temperature (up to 25° C or 77° F).</p>	<ul style="list-style-type: none"> <li>• GI intolerance, nausea, vomiting, diarrhea</li> <li>• Pancreatitis</li> <li>• Asthenia</li> <li>• Hyperlipidemia (especially hypertriglyceridemia)</li> <li>• Serum transaminase elevation</li> <li>• Hyperglycemia</li> <li>• Insulin resistance/diabetes mellitus</li> <li>• Fat maldistribution</li> <li>• Possible increased bleeding episodes in patients with hemophilia</li> <li>• PR interval prolongation</li> <li>• QT interval prolongation and torsades de pointes have been reported; however, causality could not be established.</li> </ul>
<b>Nelfinavir</b> (NFV) <i>Viracept</i>	<ul style="list-style-type: none"> <li>• 250 and 625 mg tablets</li> <li>• 50 mg/g oral powder</li> </ul>	<ul style="list-style-type: none"> <li>• 1250 mg BID, or</li> <li>• 750 mg TID</li> </ul> <p>Dissolve tablets in a small amount of water, mix admixture well, and consume immediately.</p> <p>Take with food.</p>	CYP2C19 and 3A4 substrate—metabolized to active M8 metabolite; CYP3A4 inhibitor	3.5–5 hours	Room temperature (15° to 30° C or 59° to 86° F)	<ul style="list-style-type: none"> <li>• Diarrhea</li> <li>• Hyperlipidemia</li> <li>• Hyperglycemia</li> <li>• Fat maldistribution</li> <li>• Possible increased bleeding episodes in patients with hemophilia</li> <li>• Serum transaminase elevation</li> </ul>
<b>Ritonavir</b> (RTV) <i>Norvir</i>	<ul style="list-style-type: none"> <li>• 100 mg tablet</li> <li>• 100 mg soft gel capsule</li> <li>• 80 mg/mL oral solution</li> </ul> <p>Oral solution contains 43% alcohol.</p>	<p><u>As Pharmacokinetic Booster (or Enhancer) for Other PIs:</u></p> <ul style="list-style-type: none"> <li>• 100–400 mg per day in 1 or 2 divided doses (refer to other PIs for specific dosing recommendations)</li> </ul> <p><u>Tablet:</u></p> <ul style="list-style-type: none"> <li>• Take with food.</li> </ul> <p><u>Capsule and Oral Solution:</u></p> <ul style="list-style-type: none"> <li>• To improve tolerability, take with food if possible.</li> </ul>	CYP3A4 >2D6 substrate; potent 3A4, 2D6 inhibitor; Inducer of CYPs 1A2, 2C8, 2C9, and 2C19 and UGT1A1	3–5 hours	<p>Tablets do not require refrigeration.</p> <p>Refrigerate capsules.</p> <p>Capsules can be left at room temperature (up to 25° C or 77° F) for up to 30 days.</p> <p><b>Oral solution should not be refrigerated.</b></p>	<ul style="list-style-type: none"> <li>• GI intolerance, nausea, vomiting, diarrhea</li> <li>• Paresthesia (circumoral and extremities)</li> <li>• Hyperlipidemia (especially hypertriglyceridemia)</li> <li>• Hepatitis</li> <li>• Asthenia</li> <li>• Taste perversion</li> <li>• Hyperglycemia</li> <li>• Fat maldistribution</li> <li>• Possible increased bleeding episodes in patients with hemophilia</li> </ul>

**Appendix B, Table 3. Characteristics of Protease Inhibitors (Last updated April 8, 2015; last reviewed April 8, 2015) (page 4 of 4)**

Generic Name (Abbreviation) Trade Name	Formulations	Dosing Recommendations <sup>a</sup>	Elimination/ Metabolic Pathway	Serum Half- Life	Storage	Adverse Events <sup>b</sup>
<b>Saquinavir</b> (SQV) <i>Invirase</i>	<ul style="list-style-type: none"> <li>• 500 mg tablet</li> <li>• 200 mg capsule</li> </ul>	(SQV 1000 mg plus RTV 100 mg) BID  Unboosted SQV is <b>not</b> recommended.  Take with meals or within 2 hours after a meal.	CYP3A4 substrate	1–2 hours	Room temperature (15° to 30° C or 59° to 86° F)	<ul style="list-style-type: none"> <li>• GI intolerance, nausea, and diarrhea</li> <li>• Headache</li> <li>• Serum transaminase elevation</li> <li>• Hyperlipidemia</li> <li>• Hyperglycemia</li> <li>• Fat maldistribution</li> <li>• Possible increased bleeding episodes in patients with hemophilia</li> <li>• PR interval prolongation</li> <li>• QT interval prolongation, torsades de pointes have been reported. Patients with pre-SQV QT interval &gt;450 msec should not receive SQV.</li> </ul>
<b>Tipranavir</b> (TPV) <i>Aptivus</i>	<ul style="list-style-type: none"> <li>• 250 mg capsule</li> <li>• 100 mg/mL oral solution</li> </ul>	(TPV 500 mg plus RTV 200 mg) BID  Unboosted TPV is <b>not</b> recommended.  <u>With RTV Tablets:</u> <ul style="list-style-type: none"> <li>• Take with meals.</li> </ul> <u>With RTV Capsules or Solution:</u> <ul style="list-style-type: none"> <li>• Take without regard to meals.</li> </ul>	CYP P450 3A4 inducer and substrate  CYP2D6 inhibitor; CYP3A4, 1A2, and 2C19 inducer  Net effect when combined with RTV (CYP3A4, 2D6 inhibitor)	6 hours after single dose of TPV/r	Refrigerate capsules.  Capsules can be stored at room temperature (25° C or 77° F) for up to 60 days.  <b>Oral solution should not be refrigerated or frozen</b> and should be used within 60 days after bottle is opened.	<ul style="list-style-type: none"> <li>• Hepatotoxicity: Clinical hepatitis (including hepatic decompensation and hepatitis-associated fatalities) has been reported; monitor patients closely, especially those with underlying liver diseases.</li> <li>• Skin rash (3% to 21%): TPV has a sulfonamide moiety; use with caution in patients with known sulfonamide allergy.</li> <li>• Rare cases of fatal and nonfatal intracranial hemorrhages have been reported. Risks include brain lesion, head trauma, recent neurosurgery, coagulopathy, hypertension, alcoholism, and the use of anti-coagulant or anti-platelet agents (including vitamin E).</li> <li>• Hyperlipidemia</li> <li>• Hyperglycemia</li> <li>• Fat maldistribution</li> <li>• Possible increased bleeding episodes in patients with hemophilia</li> </ul>

<sup>a</sup> For dosage adjustment in hepatic insufficiency, see [Appendix B, Table 7](#).

<sup>b</sup> Also see [Table 14](#).

**Key to Acronyms:** APV = amprenavir; ARV = antiretroviral; ATV = atazanavir; ATV/c = atazanavir/cobicistat; AV = atrioventricular; BID = twice daily; COBI = cobicistat; CYP = cytochrome P; DRV = darunavir; DRV/c = darunavir/cobicistat; EFV = efavirenz; FPV = fosamprenavir; GI = gastrointestinal; IDV = indinavir; LPV = lopinavir; LPV/r = lopinavir/ritonavir; msec = millisecond; NFV = nelfinavir; NVP = nevirapine; PI = protease inhibitor; PK = pharmacokinetic; PPI = proton pump inhibitor; RTV = ritonavir; SQV = saquinavir; TDF = tenofovir disoproxil fumarate; TID = three times a day; TPV = tipranavir

**Appendix B, Table 4. Characteristics of Integrase Inhibitors (Last updated April 8, 2015; last reviewed April 8, 2015)**

Generic Name (Abbreviation) Trade Name	Formulations	Dosing Recommendations <sup>a</sup>	Elimination/ Metabolic Pathways	Serum Half- Life	Adverse Events <sup>b</sup>
<b>Dolutegravir</b> (DTG) <i>Tivicay</i>  <b>Also available as a component of fixed-dose combination.</b>	<ul style="list-style-type: none"> <li>• 50 mg tablet</li> </ul>	<u>ARV-Naive or ARV-Experienced, INSTI-Naive Patients:</u> <ul style="list-style-type: none"> <li>• 50 mg once daily</li> </ul> <u>ARV-Naive or ARV-Experienced, INSTI-Naive Patients when CoAdministered with EFV, FPV/r, TPV/r, or RPV/r:</u> <ul style="list-style-type: none"> <li>• 50 mg BID</li> </ul> <u>INSTI-Experienced Patients with Certain INSTI Mutations (See Product Label) or with Clinically Suspected INSTI Resistance:</u> <ul style="list-style-type: none"> <li>• 50 mg BID</li> </ul> Take without regard to meals.	UGT1A1 mediated glucuronidation  Minor contribution from CYP3A4	~14 hours	<ul style="list-style-type: none"> <li>• HSRs including rash, constitutional symptoms, and organ dysfunction (including liver injury) have been reported.</li> <li>• Insomnia</li> <li>• Headache</li> </ul>
<i>Triumeq</i> DTG/ABC/3TC	<u>Triumeq:</u> <ul style="list-style-type: none"> <li>• (DTG 50 mg plus 3TC 300 mg plus ABC 600 mg) tablet</li> </ul>	<u>Triumeq:</u> Take 1 tablet daily without regard to meals.			
<b>Elvitegravir</b> (EVG) <i>Vitekta</i>  <b>Also available as a component of fixed-dose combination.</b>	85 and 150 mg tablets	<u>With Once Daily ATV/r or BID LPV/r:</u> <ul style="list-style-type: none"> <li>• 85 mg once daily with food</li> </ul> <u>With BID DRV/r, FPV/r, or TPV/r:</u> <ul style="list-style-type: none"> <li>• 150 mg once daily with food</li> </ul> Unboosted EVG is <b>not recommended</b> .	CYP3A, UGT1A1/3 substrate	~9 hours	<ul style="list-style-type: none"> <li>• Nausea</li> <li>• Diarrhea</li> </ul>
<i>Stribild</i> EVG/c/FTC/TDF	<u>Stribild:</u> <ul style="list-style-type: none"> <li>• (EVG 150 mg plus COBI 150 mg plus FTC 200 mg plus TDF 300 mg) tablet</li> </ul>	<u>Stribild:</u> 1 tablet once daily with food. Not recommended for patients with baseline CrCl < 70 mL/min (see <a href="#">Appendix B Table 7</a> for the equation for calculating CrCl).  <b>Not recommended for use with other antiretroviral drugs.</b>	EVG: As above  COBI: CYP3A, CYP2D6 (minor); CYP3A inhibitor	~13 hours	<ul style="list-style-type: none"> <li>• Nausea</li> <li>• Diarrhea</li> <li>• New onset or worsening renal impairment</li> <li>• Potential decrease in bone mineral density</li> <li>• Severe acute exacerbation of hepatitis may occur in HBV-coinfected patients who discontinue FTC and TDF.</li> </ul>
<b>Raltegravir</b> (RAL) <i>Isentress</i>	<ul style="list-style-type: none"> <li>• 400 mg tablet</li> <li>• 25 and 100 mg chewable tablets</li> <li>• 100 mg single packet for oral suspension</li> </ul>	400 mg BID  <u>With Rifampin:</u> <ul style="list-style-type: none"> <li>• 800 mg BID</li> </ul> Take without regard to meals.	UGT1A1-mediated glucuronidation	~9 hours	<ul style="list-style-type: none"> <li>• Rash, including Stevens-Johnson syndrome, HSR, and toxic epidermal necrolysis</li> <li>• Nausea</li> <li>• Headache</li> <li>• Diarrhea</li> <li>• Pyrexia</li> <li>• CPK elevation, muscle weakness, and rhabdomyolysis</li> <li>• Insomnia</li> </ul>

<sup>a</sup> For dosage adjustment in hepatic insufficiency, see [Appendix, Table 7](#).

<sup>b</sup> Also see [Table 14](#).

**Key to Abbreviations:** 3TC = lamivudine; ABC = abacavir; ARV = antiretroviral; ATV/r = atazanavir/ritonavir; BID = twice daily; c, COBI = cobicistat; CPK = creatine phosphokinase; CrCl = creatinine clearance; CYP = cytochrome P; DRV/r = darunavir/ritonavir; DTG = dolutegravir; EFV = efavirenz; EVG = elvitegravir; FPV/r = fosamprenavir/ritonavir; FTC = emtricitabine; HBV = hepatitis B virus; HSR = hypersensitivity reaction; INSTI = integrase strand transfer inhibitor; LPV/r = lopinavir/ritonavir; RAL = raltegravir; TDF = tenofovir disoproxil fumarate; TPV/r = tipranavir/ritonavir; UGT = uridine diphosphate glucosyltransferase

**Appendix B, Table 5. Characteristics of Fusion Inhibitor (Last updated January 29, 2008; last reviewed April 8, 2015)**

Generic Name (Abbreviation) Trade Name	Formulation	Dosing Recommendation	Serum Half- Life	Elimination	Storage	Adverse Events <sup>a</sup>
<b>Enfuvirtide</b> (T20) <i>Fuzeon</i>	<ul style="list-style-type: none"> <li>Injectable; supplied as lyophilized powder</li> <li>Each vial contains 108 mg of T20; reconstitute with 1.1mL of sterile water for injection for delivery of approximately 90 mg/1 mL.</li> </ul>	90 mg (1 mL) subcutaneously BID	3.8 hours	Expected to undergo catabolism to its constituent amino acids, with subsequent recycling of the amino acids in the body pool	Store at room temperature (up to 25° C or 77° F). Re-constituted solution should be refrigerated at 2° to 8° C (36° to 46° F) and used within 24 hours.	<ul style="list-style-type: none"> <li>Local injection site reactions (e.g., pain, erythema, induration, nodules and cysts, pruritus, ecchymosis) in almost 100% of patients</li> <li>Increased incidence of bacterial pneumonia</li> <li>HSR (&lt;1% of patients): Symptoms may include rash, fever, nausea, vomiting, chills, rigors, hypotension, or elevated serum transaminases. Re-challenge is not recommended.</li> </ul>

<sup>a</sup> Also see [Table 14](#).

**Key to Abbreviations:** BID = twice daily; HSR = hypersensitivity reaction; T20 = enfuvirtide

**Appendix B, Table 6. Characteristics of CCR5 Antagonist (Last updated March 27, 2012; last reviewed April 8, 2015)**

Generic Name (Abbreviation)/ Trade Name	Formulation	Dosing Recommendations <sup>a</sup>	Serum Half-Life	Elimination/ Metabolic Pathway	Adverse Events <sup>b</sup>
<b>Maraviroc</b> (MVC) <i>Selzentry</i>	150 and 300 mg tablets	<p><b>150 mg BID</b> when given with drugs that are strong CYP3A inhibitors (with or without CYP3A inducers) including PIs (except TPV/r)</p> <p><b>300 mg BID</b> when given with NRTIs, T20, TPV/r, NVP, RAL, and other drugs that are not strong CYP3A inhibitors or inducers</p> <p><b>600 mg BID</b> when given with drugs that are CYP3A inducers, including EFV, ETR, etc. (without a CYP3A inhibitor)</p> <p>Take without regard to meals.</p>	14–18 hours	CYP3A4 substrate	<ul style="list-style-type: none"> <li>Abdominal pain</li> <li>Cough</li> <li>Dizziness</li> <li>Musculoskeletal symptoms</li> <li>Pyrexia</li> <li>Rash</li> <li>Upper respiratory tract infections</li> <li>Hepatotoxicity, which may be preceded by severe rash or other signs of systemic allergic reactions</li> <li>Orthostatic hypotension, especially in patients with severe renal insufficiency</li> </ul>

<sup>a</sup> For dosage adjustment in hepatic insufficiency, see [Appendix, Table 7](#).

<sup>b</sup> Also see [Table 14](#).

**Key to Abbreviations:** BID = twice daily; CYP = cytochrome P; EFV = efavirenz; ETR = etravirine; MVC = maraviroc; NRTI = nucleoside reverse transcriptase inhibitor; NVP = nevirapine; PI = protease inhibitor; RAL = raltegravir; T20 = enfuvirtide; TPV/r = tipranavir/ritonavir



**Appendix B, Table 7. Antiretroviral Dosing Recommendations in Patients with Renal or Hepatic Insufficiency (Last updated May 1, 2014; last reviewed April 8, 2015) (page 1 of 6)**

See the reference section at the end of this table for creatinine clearance (CrCl) calculation formulas and criteria for Child-Pugh classification.

ARVs Generic Name (Abbreviation) Trade Name	Usual Daily Dose <sup>a</sup>	Dosing in Renal Insufficiency <sup>b</sup>	Dosing in Hepatic Impairment		
NRTIs					
Stribild should not be initiated in patients with CrCl <70 mL/min. Use of the following fixed-dose combinations is not recommended in patients with CrCl <50 mL/min: Atripla, Combivir, Complera, Epzicom, Stribild, Triumeq, or Trizivir. Use of Truvada is not recommended in patients with CrCl <30 mL/min.					
Abacavir (ABC) Ziagen	300 mg PO BID	No dosage adjustment necessary	Child-Pugh Score 5–6: • 200 mg PO BID (use oral solution) Child-Pugh Score >6: • Contraindicated		
Didanosine EC (ddl) Videx EC	Body Weight ≥60 kg: • 400 mg PO once daily  Body Weight <60 kg: • 250 mg PO once daily	Dose (Once Daily)		No dosage adjustment necessary.	
		CrCl (mL/min)	≥60 kg		<60 kg
		30–59	200 mg		125 mg
		10–29	125 mg		125 mg
<10, HD <sup>c</sup> , CAPD	125 mg	75 mg oral solution			
Didanosine Oral Solution (ddl) Videx	Body Weight ≥60 kg: • 200 mg PO BID, or • 400 mg PO once daily  Body Weight <60 kg: • 250 mg PO once daily, or • 125 mg PO BID	Dose (Once Daily)		No dosage adjustment necessary.	
		CrCl (mL/min)	≥60 kg		<60 kg
		30–59	200 mg		150 mg
		10–29	150 mg		100 mg
<10, HD <sup>c</sup> , CAPD	100 mg	75 mg			
Emtricitabine (FTC) Emtriva	200 mg oral capsule once daily  or  240 mg (24 mL) oral solution once daily	Dose		No dosage recommendation.	
		CrCl (mL/min)	Capsule		Solution
		30–49	200 mg q48h		120 mg q24h
		15–29	200 mg q72h		80 mg q24h
<15 or on HD <sup>c</sup>	200 mg q96h	60 mg q24h			
Lamivudine (3TC) Epivir	300 mg PO once daily  or  150 mg PO BID	CrCl (mL/min)	Dose		No dosage adjustment necessary.
		30–49	150 mg q24h		
		15–29	1 x 150 mg, then 100 mg q24h		
		5–14	1 x 150 mg, then 50 mg q24h		
		<5 or on HD <sup>c</sup>	1 x 50 mg, then 25 mg q24h		

**Appendix B, Table 7. Antiretroviral Dosing Recommendations in Patients with Renal or Hepatic Insufficiency (Last updated May 1, 2014; last reviewed April 8, 2015) (page 2 of 6)**

ARVs Generic Name (Abbreviation) Trade Name	Usual Daily Dose <sup>a</sup>	Dosing in Renal Insufficiency <sup>b</sup>			Dosing in Hepatic Impairment
NRTIs, continued					
Stavudine (d4T) Zerit	Body Weight ≥60 kg: • 40 mg PO BID  Body Weight <60 kg: • 30 mg PO BID	Dose			No dosage recommendation.
		CrCl (mL/min)	≥60 kg	<60 kg	
		26–50	20 mg q12h	15 mg q12h	
		10–25 or on HD <sup>c</sup>	20 mg q24h	15 mg q24h	
Tenofovir Disoproxil Fumarate (TDF) Viread	300 mg PO once daily	CrCl (mL/min)	Dose		No dosage adjustment necessary.
		30–49	300 mg q48h		
		10–29	300 mg twice weekly (every 72–96 hours)		
		<10 and not on HD	No recommendation		
		On HD <sup>c</sup>	300 mg q7d		
Emtricitabine (FTC) plus Tenofovir Disoproxil Fumarate (TDF) Truvada	1 tablet PO once daily	CrCl (mL/min)	Dose		No dosage recommendation.
		30–49	1 tablet q48h		
		<30 or on HD	Not recommended		
Zidovudine (AZT, ZDV) Retrovir	300 mg PO BID	CrCl (mL/min)	Dose		No dosage recommendation.
		<15 or on HD <sup>c</sup>	100 mg TID or 300 mg once daily		
NNRTIs					
Delavirdine (DLV) Rescriptor	400 mg PO TID	No dosage adjustment necessary.			No dosage recommendation; use with caution in patients with hepatic impairment.
Efavirenz (EFV) Sustiva	600 mg PO once daily, at or before bedtime	No dosage adjustment necessary.			No dosage recommendation; use with caution in patients with hepatic impairment.
Efavirenz (EFV) plus Tenofovir Disoproxil Fumarate (TDF) plus Emtricitabine (FTC) Atripla	1 tablet PO once daily	Not recommended for use in patients with CrCl <50 mL/min. Instead use the individual drugs of the fixed-dose combination and adjust TDF and FTC doses according to CrCl level.			

**Appendix B, Table 7. Antiretroviral Dosing Recommendations in Patients with Renal or Hepatic Insufficiency (Last updated May 1, 2014; last reviewed April 8, 2015) (page 3 of 6)**

ARVs Generic Name (Abbreviation) Trade Name	Usual Daily Dose <sup>a</sup>	Dosing in Renal Insufficiency <sup>b</sup>	Dosing in Hepatic Impairment
<b>NNRTIs, continued</b>			
<b>Etravirine</b> (ETR) <i>Intelligence</i>	200 mg PO BID	No dosage adjustment necessary.	<u>Child-Pugh Class A or B:</u> • No dosage adjustment  <u>Child-Pugh Class C:</u> • No dosage recommendation
<b>Nevirapine</b> (NVP) <i>Viramune</i> or <i>Viramune XR</i>	200 mg PO BID or 400 mg PO once daily (using Viramune XR formulation)	<u>Patients on HD:</u> • Limited data; no dosage recommendation.	<u>Child-Pugh Class A:</u> • No dosage adjustment  <u>Child-Pugh Class B or C:</u> • Contraindicated
<b>Rilpivirine</b> (RPV) <i>Edurant</i>	25 mg PO once daily	No dosage adjustment necessary.	<u>Child-Pugh Class A or B:</u> • No dosage adjustment  <u>Child-Pugh Class C:</u> • No dosage recommendation
<b>Rilpivirine (RPV)</b> plus <b>Tenofovir Disoproxil Fumarate (TDF)</b> plus <b>Emtricitabine (FTC)</b> <i>Complera</i>	1 tablet PO once daily	Not recommended for use in patients with CrCl <50 mL/min. Instead use the individual drugs of the fixed-dose combination and adjust TDF and FTC doses levels according to CrCl level.	<u>Child-Pugh Class A or B:</u> • No dosage adjustment  <u>Child-Pugh Class C:</u> • No dosage recommendation
<b>PIs</b>			
<b>Atazanavir</b> (ATV) <i>Reyataz</i>	400 mg PO once daily or (ATV 300 mg plus RTV 100 mg) PO once daily	No dosage adjustment for patients with renal dysfunction who do not require HD.  <u>ARV-Naive Patients on HD:</u> • (ATV 300 mg plus RTV 100 mg) once daily  <u>ARV-Experienced Patients on HD:</u> • ATV or ATV/r not recommended	<u>Child-Pugh Class B:</u> • 300 mg once daily  <u>Child-Pugh Class C:</u> • Not recommended  RTV boosting is <b>not</b> recommended in patients with hepatic impairment (Child-Pugh Class B or C).
<b>Atazanavir</b> (ATV) plus <b>Cobicistat</b> (COBI) <i>Evotaz</i>	1 tablet PO once daily	<u>If Used with TDF:</u> • Not recommended for use in patients with CrCl <70 mL/min.  <u>If Not Used with TDF:</u> • No dosage adjustment for patients with renal dysfunction who do not require HD.	No dosage recommendation; not recommended in patients with hepatic impairment.

**Appendix B, Table 7. Antiretroviral Dosing Recommendations in Patients with Renal or Hepatic Insufficiency (Last updated May 1, 2014; last reviewed April 8, 2015) (page 4 of 6)**

ARVs Generic Name (Abbreviation) Trade Name	Usual Daily Dose <sup>a</sup>	Dosing in Renal Insufficiency <sup>b</sup>	Dosing in Hepatic Impairment
<b>PIs, continued</b>			
<b>Darunavir</b> (DRV) <i>Prezista</i>	<u>ARV-Naive Patients and ARV-Experienced Patients with No DRV Resistance Mutations:</u> • (DRV 800 mg plus RTV 100 mg) PO once daily  <u>ARV-Experienced Patients with at Least One DRV Resistance Mutation:</u> • (DRV 600 mg plus RTV 100 mg) PO BID	No dosage adjustment necessary.	<u>Mild-to-Moderate Hepatic Impairment:</u> • No dosage adjustment  <u>Severe Hepatic Impairment:</u> • Not recommended
<b>Darunavir</b> (DRV) plus <b>Cobicistat</b> (COBI) <i>Prezcobix</i>	1 tablet PO once daily (only recommended for patients without DRV-associated resistance mutations)	<u>If Used with TDF:</u> • Not recommended for use in patients with CrCl <70 mL/min.  <u>If Not Used with TDF:</u> • No dosage adjustment necessary.	<u>Child-Pugh Class A or B:</u> • No dosage adjustment  <u>Child-Pugh Class C:</u> • Not recommended
<b>Fosamprenavir</b> (FPV) <i>Lexiva</i>	1400 mg PO BID or (FPV 1400 mg plus RTV 100–200 mg) PO once daily or (FPV 700 mg plus RTV 100 mg) PO BID	No dosage adjustment necessary.	<u>PI-Naive Patients Only:</u> <u>Child-Pugh Score 5–9:</u> • 700 mg BID  <u>Child-Pugh Score 10–15:</u> • 350 mg BID  <u>PI-Naive or PI-Experienced Patients:</u> <u>Child-Pugh Score 5–6:</u> • (700 mg BID plus RTV 100 mg) once daily  <u>Child-Pugh Score 7–9:</u> • (450 mg BID plus RTV 100 mg) once daily  <u>Child-Pugh Score 10–15:</u> • (300 mg BID plus RTV 100 mg) once daily
<b>Indinavir</b> (IDV) <i>Crixivan</i>	800 mg PO q8h	No dosage adjustment necessary.	<u>Mild-to-Moderate Hepatic Insufficiency Because of Cirrhosis:</u> • 600 mg q8h

**Appendix B, Table 7. Antiretroviral Dosing Recommendations in Patients with Renal or Hepatic Insufficiency (Last updated May 1, 2014; last reviewed April 8, 2015) (page 5 of 6)**

<b>ARVs Generic Name (Abbreviation) Trade Name</b>	<b>Usual Daily Dose<sup>a</sup></b>	<b>Dosing in Renal Insufficiency<sup>b</sup></b>	<b>Dosing in Hepatic Impairment</b>
<b>PIs, continued</b>			
<b>Lopinavir/ritonavir</b> (LPV/r) <i>Kaletra</i>	(LPV 400 mg plus RTV 100 mg) PO BID or (LPV 800 mg plus RTV 200 mg) PO once daily	Avoid once-daily dosing in patients on HD.	No dosage recommendation; use with caution in patients with hepatic impairment.
<b>Nelfinavir</b> (NFV) <i>Viracept</i>	1250 mg PO BID	No dosage adjustment necessary.	<u>Mild hepatic impairment:</u> • No dosage adjustment <u>Moderate-to-severe hepatic impairment:</u> • Do not use.
<b>Ritonavir</b> (RTV) <i>Norvir</i>	<u>As a PI-Boosting Agent:</u> • 100–400 mg per day	No dosage adjustment necessary.	Refer to recommendations for the primary PI.
<b>Saquinavir</b> (SQV) <i>Invirase</i>	(SQV 1000 mg plus RTV 100 mg) PO BID	No dosage adjustment necessary.	<u>Mild-to-Moderate Hepatic Impairment:</u> • Use with caution. <u>Severe Hepatic Impairment:</u> • Contraindicated
<b>Tipranavir</b> (TPV) <i>Aptivus</i>	(TPV 500 mg plus RTV 200 mg) PO BID	No dosage adjustment necessary.	<u>Child-Pugh Class A:</u> • Use with caution <u>Child-Pugh Class B or C:</u> • Contraindicated
<b>INSTIs</b>			
<b>Dolutegravir</b> (DTG) <i>Tivicay</i>	50 mg once daily or 50 mg BID	No dosage adjustment necessary.	<u>Child-Pugh Class A or B:</u> • No dosage adjustment <u>Child-Pugh Class C:</u> • Not recommended
<b>Elvitegravir</b> (EVG) <i>Vitekta</i>	85 mg or 150 mg <sup>a</sup> once daily	No dosage adjustment necessary.	<u>Child-Pugh Class A or B:</u> • No dosage adjustment <u>Child-Pugh Class C:</u> • Not recommended

**Appendix B, Table 7. Antiretroviral Dosing Recommendations in Patients with Renal or Hepatic Insufficiency (Last updated May 1, 2014; last reviewed April 8, 2015) (page 6 of 6)**

ARVs Generic Name (Abbreviation) Trade Name	Usual Daily Dose <sup>a</sup>	Dosing in Renal Insufficiency <sup>b</sup>	Dosing in Hepatic Impairment
<b>INSTIs, continued</b>			
<b>Elvitegravir (EVG)</b> plus <b>Cobicistat (COBI)</b> plus <b>Tenofovir Disoproxil Fumarate (TDF)</b> plus <b>Emtricitabine (FTC)</b> <i>Stribild</i>	1 tablet once daily	EVG/c/TDF/FTC <b>should not be initiated</b> in patients with CrCl <70 mL/min.  Discontinue EVG/c/TDF/FTC if CrCl declines to <50 mL/min while patient is on therapy.	<u>Mild-to-Moderate Hepatic Insufficiency:</u> • No dosage adjustment necessary  <u>Severe Hepatic Insufficiency:</u> • Not recommended
<b>Raltegravir (RAL)</b> <i>Isentress</i>	400 mg BID	No dosage adjustment necessary.	<u>Mild-to-Moderate Hepatic Insufficiency:</u> • No dosage adjustment necessary  <u>Severe Hepatic Insufficiency:</u> • No recommendation
<b>Fusion Inhibitor</b>			
<b>Enfuvirtide (T20)</b> <i>Fuzeon</i>	90 mg subcutaneous BID	No dosage adjustment necessary.	No dosage adjustment necessary
<b>CCR5 Antagonist</b>			
<b>Maraviroc (MVC)</b> <i>Selzentry</i>	The recommended dose differs based on concomitant medications and potential for drug-drug interactions. See <a href="#">Appendix B, Table 6</a> for detailed dosing information.	<u>CrCl &lt;30 mL/min or on HD</u> <i>Without Potent CYP3A Inhibitors or Inducers:</i> • 300 mg BID; reduce to 150 mg BID if postural hypotension occurs  <i>With Potent CYP3A Inducers or Inhibitors:</i> • Not recommended	No dosage recommendations. Concentrations will likely be increased in patients with hepatic impairment.

<sup>a</sup> Refer to [Appendix B, Tables 1–6](#) for additional dosing information

<sup>b</sup> Including with chronic ambulatory peritoneal dialysis and hemodialysis

<sup>c</sup> On dialysis days, take dose after HD session

**Key to Abbreviations:** 3TC = lamivudine; ABC = abacavir; ARV = antiretroviral; ATV = atazanavir; AZT = zidovudine; BID = twice daily; CAPD = chronic ambulatory peritoneal dialysis; COBI, c = cobicistat; CrCl = creatinine clearance; CYP = cytochrome P; d4T = stavudine; ddI = didanosine; DLV = delavirdine; DRV = darunavir; EC = enteric coated; DTG = dolutegravir; EFV = efavirenz; ETR = etravirine; EVG = elvitegravir; FPV = fosamprenavir; FTC = emtricitabine; HD = hemodialysis; IDV = indinavir; LPV/r = lopinavir/ritonavir; MVC = maraviroc; NFV = nelfinavir; NNRTI = non-nucleoside reverse transcriptase inhibitor; NRTI = nucleoside reverse transcriptase inhibitor; NVP = nevirapine; PI = protease inhibitor; PO = orally; q(n)d = every (n) days; q(n)h = every (n) hours; RAL = raltegravir; RPV = rilpivirine; RTV = ritonavir; SQV = saquinavir; T20 = enfuvirtide; TDF = tenofovir disoproxil fumarate; TID = three times daily; TPV = tipranavir; XR = extended release; ZVD = zidovudine



Creatinine Clearance Calculation	
Male: $\frac{(140 - \text{age in years}) \times (\text{weight in kg})}{72 \times (\text{serum creatinine})}$	Female: $\frac{(140 - \text{age in years}) \times (\text{weight in kg}) \times (0.85)}{72 \times (\text{serum creatinine})}$

Child-Pugh Score			
Component	Points Scored		
	1	2	3
Encephalopathy <sup>a</sup>	None	Grade 1–2	Grade 3–4
Ascites	None	Mild or controlled by diuretics	Moderate or refractory despite diuretics
Albumin	>3.5 g/dL	2.8–3.5 g/dL	<2.8 g/dL
Total bilirubin or	<2 mg/dL (<34 μmol/L)	2–3 mg/dL (34 μmol/L to 50 μmol/L)	>3 mg/dL (>50 μmol/L)
Modified total bilirubin <sup>b</sup>	<4 mg/dL	4–7 mg/dL	>7 mg/dL
Prothrombin time (seconds prolonged) or	<4	4–6	>6
International normalized ratio (INR)	<1.7	1.7–2.3	>2.3

<sup>a</sup> Encephalopathy Grades

**Grade 1:** Mild confusion, anxiety, restlessness, fine tremor, slowed coordination

**Grade 2:** Drowsiness, disorientation, asterixis

**Grade 3:** Somnolent but rousable, marked confusion, incomprehensible speech, incontinence, hyperventilation

**Grade 4:** Coma, decerebrate posturing, flaccidity

<sup>b</sup> Modified total bilirubin used for patients who have Gilbert's syndrome or who are taking indinavir or atazanavir

Child-Pugh Classification	Total Child-Pugh Score <sup>c</sup>
Class A	5–6 points
Class B	7–9 points
Class C	>9 points

<sup>c</sup> Sum of points for each component