Drug Susceptibility in HIV Infection After Viral Rebound in Patients Receiving Indinavir-Containing Regimens

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Complete and prolonged suppression of human immunodeficiency virus (HIV) replication is a primary objective of antiretroviral therapy. Rates of viral suppression achieved by potent combination therapies exceed 90% in select clinical trial groups, but these rates are less with the same regimens outside research settings. Rebound of plasma viremia also may occur after having suppression below level of detectability. Major factors contributing to loss of suppression include suboptimal drug potency, inadequate drug exposure, and insufficient regimen adherence. A large increase in CD4 cells with therapy, providing more target cells for virus replication, has been proposed and observed to contribute to loss of suppression.

Resistance to protease inhibitor (PI) monotherapy is characterized by sequential acquisition of mutations conferring stepwise reductions in drug susceptibility. Early mutant virus appears to be fitness-disadvantaged vs wild-type virus, but later mutations in protease and gag cleavage sites appear to compensate for this. Early reports of PI resistance featured patients failing monotherapy or having a PI added to their regimen. Multiple protease-resistance mutations were present in virus isolated from these patients.

Context  Loss of viral suppression in patients infected with human immunodeficiency virus (HIV), who are receiving potent antiretroviral therapy, has been attributed to outgrowth of drug-resistant virus; however, resistance patterns are not well characterized in patients whose protease inhibitor combination therapy fails after achieving viral suppression.

Objective  To characterize drug susceptibility of virus from HIV-infected patients who are failing to sustain suppression while taking an indinavir-containing antiretroviral regimen.

Design and Setting  Substudy of the AIDS Clinical Trials Group 343, a multicenter clinical research trial conducted between February 1997 and October 1998.

Patients  Twenty-six subjects who experienced rebound (HIV RNA level ≥200 copies/mL) during indinavir monotherapy (n = 9) or triple-drug therapy (indinavir, lamivudine, and zidovudine; n = 17) after initially achieving suppression while receiving all 3 drugs, and 10 control subjects who had viral suppression while receiving triple-drug therapy.

Main Outcome Measure  Drug susceptibility, determined by a phenotypic assay and genotypic evidence of resistance assessed by nucleotide sequencing of protease and reverse transcriptase, compared among the 3 patient groups.

Results  Indinavir resistance was not detected in the 9 subjects with viral rebound during indinavir monotherapy or in the 17 subjects with rebound during triple-drug therapy, despite plasma HIV RNA levels ranging from 10^2 to 10^5 copies/mL. In contrast, lamivudine resistance was detected by phenotypic assay in rebound isolates from 14 of 17 subjects receiving triple-drug therapy, and genotypic analyses showed changes at codon 184 of reverse transcriptase in these 14 isolates. Mean random plasma indinavir concentrations in the 2 groups with rebound were similar to those of a control group with sustained viral suppression, although levels below 50 ng/mL were more frequent in the triple-drug group than in the control group (P = .03).

Conclusions  Loss of viral suppression may be due to suboptimal antiviral potency, and selection of a predominantly indinavir-resistant virus population may be delayed for months even in the presence of ongoing indinavir therapy. The results suggest possible value in assessing strategies using drug components of failing regimens evaluated with resistance testing.

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See also pp 205 and 250.
ever, these patients’ regimens had not suppressed the virus fully, thus providing opportunity for selection of virus with resistance mutations. Resistance patterns in patients failing PI combination therapy following suppression are less well characterized.

We describe drug susceptibility in 26 trial participants achieving suppression with indinavir when rebound was observed. Nine patients were receiving only indinavir when rebound was observed.

**METHODS**

**Subjects**

Subjects were a subset of the AIDS Clinical Trials Group 343 (ACTG 343) participants (for whom eligibility criteria were CD4 cells ≥200 × 10^3/L, HIV RNA level ≥1000 copies/mL, limited treatment [<7 days] with PIs, and no prior treatment with lamivudine or abacavir). The goal for ACTG 343 was to assess whether suppression achieved by potent triple-drug therapy could be sustained with less intensive therapy. Subjects (n = 309) were prescribed 6 months of open-label induction therapy with indinavir, 800 mg every 8 hours, lamivudine, 150 mg twice daily, and zidovudine, 300 mg twice daily. Levels of HIV RNA were assayed at 4-week intervals. Treatment discontinuation was recorded but detailed adherence studies were not performed. Subjects with HIV RNA levels less than 200 copies/mL after 16, 20, and 24 weeks of induction therapy were randomized (blinded) in the maintenance phase to receive indinavir monotherapy (n = 100), zidovudine plus lamivudine (n = 104), or all 3 drugs (n = 105). Loss of suppression (plasma HIV RNA levels of ≥200 copies/mL) was the primary study end point. Subjects reaching a study end point had the option to resume triple-drug therapy. Of those receiving indinavir and those receiving zidovudine plus lamivudine, 23% in each arm had rebound early during maintenance vs 3% of those continuing triple-drug therapy.6 The first available specimens were assessed, as per resource constraints, from 9 of 23 subjects (indinavir group) with rebound after switching to indinavir, 17 of 75 subjects (triple-drug therapy group) with at least 1 HIV RNA level of less than 200 copies/mL during induction and 10 of 178 subjects (control group) receiving triple therapy with sustained suppression throughout the trial. Subjects provided written informed consent. Given the expectation that more than 95% of subjects would have indinavir-resistant virus at virologic rebound, there was a greater than 99.9% probability that at least 1 subject in the group of 9 patients and 99.9% probability that at least 1 subject in the group of 17 would have indinavir-resistant virus at rebound.

**Phenotypic Resistance Testing**

Resistance was evaluated using a phenotypic assay for drug susceptibility (PhenoSense, ViroLogic Inc, San Francisco, Calif) on baseline and follow-up plasma samples from all patients in the indinavir, triple-drug, and control groups as previously reported.3 Drug susceptibility was quantified by determining the 50% inhibitory concentration (IC_{50}) of drug assayed in vitro of a recombinant test strain incorporating protease and reverse transcriptase gene segments from patient isolates in the presence of protease and reverse transcriptase inhibitors compared with a control (NL4-3) strain. The IC_{50} values greater than 2.5-fold those of the drug-susceptible reference strain indicated reduced susceptibility based on assay validation studies.14

**Genotypic Resistance Testing**

Sequence analysis of drug-resistance mutations in reverse transcriptase and protease genes was done using population-based sequence analysis (PE Biosystems, Foster City, Calif) on all resistance test vector plasmid pools evaluated for evidence of resistance by phenotypic assay. Amino acid substitutions identified via comparison with NL4-3 were reported. As with the PhenoSense assay, the sequencing results represent the majority species of the HIV RNA amplified from plasma, except in 1 case involving 1 subject. In a prior study evaluating the sensitivity of this method for detecting mixtures of virus pools with 5 HIV polymerase gene polymorphisms, we found that the majority population was readily detectable.15 Minority species may not be uniformly detected by this method. Resistance mutations were classified as primary or secondary based on recent consensus guidelines.16

**Indinavir Concentrations**

Indinavir concentrations were measured in a central laboratory using high-pressure liquid chromatography on plasma from 29 subjects with available banked plasma samples from time points coinciding with ACTG 343 protocol visits. After extracting indinavir with ethyl t-butyl ether, indinavir and an internal standard were back-extracted from the organic layer following acidification. Repeat extraction of indinavir and the internal standard with methyl t-butyl ether was performed after basification and the final organic was decanted and evaporated. The residue was dissolved with a phosphate buffer and acetonitrile mixture, and the extract was analyzed using high-pressure liquid chromatography with column switching. Chromatograph peaks were monitored by assessing absorbance at 210 nm.

The standard curve range for the indinavir assay ranged from 5 to 500 ng/mL. Precision and inaccuracy were 5.0% and 5.8%, respectively, at the low standard, and 1.6% and 0.7% at the high standard. The indinavir concentration was weighted by number of indinavir measures (range, 4-8) for each subject. Mean and median of indinavir values for each subject were used to generate weighted mean and median indinavir concentrations for each group. These values were compared using Kruskall-Wallis analysis of variance. The proportion of subjects with at least 1 indinavir value of less than 50 ng/mL was compared among the 3 groups using Fisher exact test.

**RESULTS**

**Drug Susceptibility With Maintenance Therapy**

During induction of triple-drug therapy, suppression below a plasma HIV RNA level of 50 copies/mL was achieved in the 9 subjects subsequently randomized to indinavir maintenance monotherapy
persons infected with HIV may have changes at these codons prior to therapy initiation. Only those substitutions confirmed, subjects were encouraged to switch to alternative antiretroviral regimens, patients chose to continue taking this triple-drug therapy despite peak HIV RNA levels during rebound. Sequencing confirmed that the methionine to valine substitution at codon 184 of reverse transcriptase, known to confer high-level resistance to lamivudine, was present in all 14 isolates. In 13 of the 14 subjects with lamivudine resistance, lamivudine susceptibility decreased by more than 100-fold at rebound vs the control isolate. In 1 of the 14 subjects, a mixture of isolates with methionine and valine were present, and susceptibility to lamivudine was 7-fold less than that in the control group. Rebound isolates were sensitive to lamivudine in 3 subjects. In analyses from a separate pharmacokinetic study (J.-P.S., unpublished data, 1999), indinavir concentrations were undetectable at weeks 12, 20, and 35 in subject 24, who had no resistance to lamivudine, suggesting prescribed medications were not taken.

**Random Indinavir Levels**

Detectable indinavir concentrations were present in 98% of samples from the indinavir group, 72% from the triple-drug group, and 82% from the control group. At least 4 samples per patient were assessed (mean, 5.4 per patient). Indinavir levels were obtained both during suppression and rebound in 7 patients in the triple-therapy group and 2 patients in the indinavir monotherapy group, and for 3 subjects who were assessed at 2 sequential time points (Table 1). Levels of HIV RNA ranged from 10² to 10⁵ copies/mL in the samples collected at the same time points used for drug susceptibility testing. Viral isolates at baseline and during rebound showed no reduction in susceptibility to indinavir or to PIs nelfinavir, ritonavir, and saquinavir.

Nucleotide sequencing detected no primary mutations known to be associated with indinavir resistance (codons 46 and 82). Changes at codons 10, 20, 24, 32, 54, 63, 71, 73, and 90 were reported in patients with indinavir resistance and classified as secondary mutations. Persons infected with HIV may have changes at these codons prior to therapy. Subjects 4 and 7 had L63P at baseline, and subjects 1 and 2 had this substitution identified in rebound isolates. Subject 3 had L10I at baseline.

After loss of suppression was confirmed, subjects were encouraged to change therapy. Five of the 9 subjects discontinued study participation after rebound was detected. Four subjects resumed open-label, triple-drug therapy with indinavir, zidovudine, and lamivudine. At the time of rebound, the viral loads had been greater than 200 copies/mL for 2 to 8 weeks. Suppression was achieved by 4 weeks in 3 subjects and sustained for 7 to 10 months. Initial suppression was lost 4 months after all 3 drugs were resumed in the fourth subject.

**Drug Susceptibility With Triple-Drug Therapy**

No significant changes in indinavir susceptibility were detected during rebound in the 17 patients receiving triple-drug therapy despite peak HIV RNA levels during rebound of 1864 to 138 989 copies/mL (Table 2) (a representative subject’s experience is illustrated in the FIGURE). The primary indinavir-resistance mutation M46L was identified in subject 24 at week 35 but not week 41. Antiretroviral therapy interruption with selective pressure shortly after the week 35 visit may explain the reappearance of wild-type virus at week 41. Secondary-resistance mutations were present at baseline at codon 63 (9 subjects), codon 10 (5 subjects), and codon 71 (2 subjects), but no new secondary indinavir-resistance mutations appeared in any rebound isolate. Duration of observation during rebound (mean, 6 months; range, 1-12 months) was longer in patients failing triple-drug therapy vs those with rebound when receiving indinavir maintenance therapy (mean, 1 month; range, 0.5-2.5). Although encouraged to switch to alternative antiretroviral regimens, patients chose to continue taking this triple-drug therapy due in part to the limited number of other regimens available at that time.

In 14 of the 17 subjects, lamivudine resistance was detected with the phenotypic assay in viral isolates obtained during rebound. Sequencing confirmed that the methionine to valine substitution at codon 184 of reverse transcriptase, known to confer high-level resistance to lamivudine, was present in all 14 isolates. In 13 of the 14 subjects with lamivudine resistance, lamivudine susceptibility decreased by more than 100-fold at rebound vs the control isolate. In 1 of the 14 subjects, a mixture of isolates with methionine and valine were present, and susceptibility to lamivudine was 7-fold less than that in the control group. Rebound isolates were sensitive to lamivudine in 3 subjects. In analyses from a separate pharmacokinetic study (J.-P.S., unpublished data, 1999), indinavir concentrations were undetectable at weeks 12, 20, and 35 in subject 24, who had no resistance to lamivudine, suggesting prescribed medications were not taken.

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**Table 1. Drug Susceptibility in Subjects With Viral Rebound Receiving Indinavir Maintenance Therapy***

<table>
<thead>
<tr>
<th>Subject</th>
<th>HIV RNA, copies/mL</th>
<th>Weeks of Indinavir Maintenance at Assay‡</th>
<th>Secondary Indinavir-Resistance Mutations§</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>168 035</td>
<td>2386</td>
<td>L63P</td>
</tr>
<tr>
<td>2</td>
<td>4570</td>
<td>37 607</td>
<td>L63P</td>
</tr>
<tr>
<td>3</td>
<td>58 586</td>
<td>14 411</td>
<td>None</td>
</tr>
<tr>
<td>4</td>
<td>8 491</td>
<td>15 900</td>
<td>None</td>
</tr>
<tr>
<td>5</td>
<td>16 095</td>
<td>1107</td>
<td>None</td>
</tr>
<tr>
<td>6</td>
<td>396</td>
<td>13 852</td>
<td>None</td>
</tr>
<tr>
<td>7</td>
<td>28 870</td>
<td>16 545</td>
<td>None</td>
</tr>
<tr>
<td>8</td>
<td>44 513</td>
<td>62 012</td>
<td>None</td>
</tr>
<tr>
<td>9</td>
<td>65 582</td>
<td>2430</td>
<td>None</td>
</tr>
</tbody>
</table>

*There were no primary indinavir-resistance mutations with substitutions at codons 46 and 82.
†Peak level of human immunodeficiency virus (HIV) RNA during rebound when the viral isolates were assayed for drug susceptibility.
‡Each isolate assayed at these time points was sensitive for indinavir susceptibility. Sensitive was defined by inhibitory concentration (IC₅₀) of drug assayed in vitro less than or equal to 2.5-fold that of control isolate; resistance was defined as IC₅₀ greater than 2.5-fold that of control.
§Substitutions at the following codons have been associated with indinavir resistance: 10, 20, 24, 32, 54, 63, 71, 73, and 90. Some patients had polymorphisms at these codons prior to therapy initiation. Only those substitutions present during rebound but not at baseline are shown here.
This isolate had a 7-fold reduction in susceptibility vs all the other resistant isolates (which had
two primary indinavir-resistance mutations except for subject 24, who had a primary muta-
tion at M46L.

Sensitive defined as 50% inhibitory concentration (IC50) of drug assayed in vitro less than twice that of control isolate;
resistance defined as IC50 2.5-fold greater than that of control.

There were no primary or secondary indinavir-resistance mutations except for subject 24, who had a primary mutation at M46L.

This isolate had a 7-fold reduction in susceptibility vs all the other resistant isolates (which had >100-fold reductions).

In earlier studies of PI resistance in patients receiving combination antiretro-
viral therapy, patients received sequential therapy and plasma HIV RNA levels were only partially suppressed.17
Under these conditions, PI-resistant virus emerged rapidly. These observations and similar ones involving PI mono-
therapy18 led to the generally held assumption that when suppression failure occurs with a regimen containing a PI,
PI-resistant virus accounts for HIV RNA rebound. Failure to detect resistance in some patients was attributed to regimen
nonadherence.19,20 The results from this study and others challenge this view and suggest that suboptimal antiviral potency
permits rebound, and that selection of a predominantly PI-resistant virus population may be delayed for months.21,22

The patients in this study had suppressed viral load to below 50 copies/mL while taking triple-drug therapy.
Suppression was then lost either when continuing triple therapy or when switching to indinavir maintenance
therapy. In both groups, indinavir levels were detectable in most samples tested and indinavir-sensitive virus was the pre-
dominant population identified during rebound. In most patients continuing to receive lamivudine as part of triple-
therapy, virus was lamivudine-resistant phenotypically and genotypically at the time of rebound. Outgrowth of indinavir-sensitive, lamivudine-

**Table 2. Drug Susceptibility in Subjects Receiving Indinavir, Zidovudine, and Lamivudine With Viral Rebound**

<table>
<thead>
<tr>
<th>Subject</th>
<th>Weeks of Viral Rebound at Assay</th>
<th>Peak HIV RNA Level During Viral Rebound, copies/mL</th>
<th>Weeks of Triple-Drug Therapy at Assay</th>
<th>Susceptibility†</th>
<th>Genotype of Codon 184V of Reverse Transcriptase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12</td>
<td>32,962</td>
<td>32, 36, 44</td>
<td>Sensitive</td>
<td>M184V</td>
</tr>
<tr>
<td>11</td>
<td>17</td>
<td>22,426</td>
<td>24, 31</td>
<td>Sensitive</td>
<td>M184V</td>
</tr>
<tr>
<td>12</td>
<td>37</td>
<td>68,659</td>
<td>30, 36, 46, 61</td>
<td>Sensitive</td>
<td>M184V</td>
</tr>
<tr>
<td>13</td>
<td>22</td>
<td>10,320</td>
<td>16, 24, 38</td>
<td>Sensitive</td>
<td>M184V/wild-type mixture</td>
</tr>
<tr>
<td>14</td>
<td>25</td>
<td>62,220</td>
<td>20, 45</td>
<td>Sensitive</td>
<td>M184V</td>
</tr>
<tr>
<td>15</td>
<td>20</td>
<td>29,966</td>
<td>24, 36, 44</td>
<td>Sensitive</td>
<td>M184V</td>
</tr>
<tr>
<td>16</td>
<td>4</td>
<td>18,64</td>
<td>16, 20</td>
<td>Sensitive</td>
<td>M184V</td>
</tr>
<tr>
<td>17</td>
<td>8</td>
<td>24,460</td>
<td>29, 38</td>
<td>Sensitive</td>
<td>M184V</td>
</tr>
<tr>
<td>18</td>
<td>19</td>
<td>39,67</td>
<td>24, 35</td>
<td>Sensitive</td>
<td>M184V</td>
</tr>
<tr>
<td>19</td>
<td>28</td>
<td>19,487</td>
<td>20, 48</td>
<td>Sensitive</td>
<td>Wild type</td>
</tr>
<tr>
<td>20</td>
<td>16</td>
<td>57,917</td>
<td>20, 28</td>
<td>Sensitive</td>
<td>M184V</td>
</tr>
<tr>
<td>21</td>
<td>36</td>
<td>10,061</td>
<td>26, 62</td>
<td>Sensitive</td>
<td>Wild type</td>
</tr>
<tr>
<td>22</td>
<td>29</td>
<td>62,40</td>
<td>49</td>
<td>Sensitive</td>
<td>M184V</td>
</tr>
<tr>
<td>23</td>
<td>46</td>
<td>1,143</td>
<td>66</td>
<td>Sensitive</td>
<td>M184V</td>
</tr>
<tr>
<td>24</td>
<td>25</td>
<td>49,697</td>
<td>35, 41</td>
<td>Sensitive</td>
<td>Wild type</td>
</tr>
<tr>
<td>25</td>
<td>24</td>
<td>138,989</td>
<td>24, 40</td>
<td>Sensitive</td>
<td>M184V</td>
</tr>
<tr>
<td>26</td>
<td>49</td>
<td>27,172</td>
<td>65</td>
<td>Sensitive</td>
<td>M184V</td>
</tr>
</tbody>
</table>

*The baseline isolates contained polymorphisms considered secondary indinavir-resistance mutations in 16 subjects and are listed in the “Results” section. HIV indicates human immunodeficiency virus.
†Sensitive defined as 50% inhibitory concentration (IC50) of drug assayed in vitro less than twice that of control isolate; resistance defined as IC50 2.5-fold greater than that of control.
‡There were no primary or secondary indinavir-resistance mutations except for subject 24, who had a primary mutation at M46L.
§This isolate had a 7-fold reduction in susceptibility vs all the other resistant isolates (which had >100-fold reductions).

**Comment**

In earlier studies of PI resistance in patients receiving combination antiretro-
viral therapy, patients received sequential therapy and plasma HIV RNA levels were only partially suppressed.17
Under these conditions, PI-resistant virus emerged rapidly. These observations and similar ones involving PI mono-
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dominant population identified during rebound. In most patients continuing to receive lamivudine as part of triple-
therapy, virus was lamivudine-resistant phenotypically and genotypically at the time of rebound. Outgrowth of indinavir-sensitive, lamivudine-
resistant virus with continuing treatment pressure may be explained by viral fitness and antiviral potency. By definition, the predominant virus replicating under a set of selective pressures is the most fit. For lamivudine or non–nucleoside reverse transcriptase inhibitors such as nevirapine or efavirenz, a single nucleotide change can confer a 20- to 1000-fold reduction in susceptibility.37-39. In the presence of drugs, the mutant virus is so much more fit that it will predominate. Clinical data confirm that when antiviral potency of a regimen containing one of these drugs is insufficient to suppress replication, drug-resistant virus rapidly emerges.27-29 Most patients failing triple therapy herein had lamivudine resistance. In a study of isolates from patients with rebound when taking an efavirenz and indinavir combination regimen, most isolates were resistant to efavirenz.30

Why did indinavir-sensitive virus appear in patients continuing therapy? Possible factors include impaired fitness of early indinavir-resistant mutant virus, reduced antiviral potency, and an increase in target cells. In contrast to lamivudine and non–nucleoside reverse transcriptase inhibitors, development of high-level resistance to PIs and lamivudine requires the accumulation of multiple mutations.9,10,31,32 For PIs, the first mutation confers only limited reduction in susceptibility, usually less than 10-fold.33 Also, the first mutations adversely affect protease function and virus replication.9,31,34 Thus, a virus with 1 or 2 mutations is less fit than wild type, even in the presence of drugs.

In those receiving indinavir maintenance therapy, reduction in antiviral potency (ie, discontinuation of zidovudine and lamivudine) allowed increased viral replication. Because the wild-type virus had a fitness advantage over early mutant virus, it was the predominant population for months. Replication may also have been enhanced by an increase in target cells. In patients randomized to maintenance therapy in ACTG 343, loss of suppression was most likely in those with the greatest increment in CD4 cell number,6 supporting predator-prey models proposed to explain viral dynamics in patients receiving zidovudine.35 The models were later extended to induction-maintenance treatment strategies.36 In these models, increased numbers of target cells resulting from treatment provide better conditions for the virus when suppression is incomplete.

Based on prior studies of indinavir monotherapy, one would expect that had patients failing indinavir maintenance therapy not been switched back to more potent regimens, indinavir-resistant virus would have become the predominant population. Continuing growth of the breakthrough virus in the presence of drug selects for an accumulation of mutations conferring both reduced susceptibility and compensation for the adverse impact of resistance mutations on protease function and virus replication. Compensatory mutations have been well characterized both in protease outside the substrate binding site and in protease cleavage sites in gag.9,31,34 The maximum period of observation of indinavir maintenance failures was 3 months. It is probable that selection of early indinavir-resistant mutant virus occurred, but that the prevalence remained below the limit of detection of the assay used to assess drug susceptibility.

In patients failing triple-drug therapy, diminished antiviral potency (as a result of suboptimal adherence or drug delivery) undoubtedly contributed to rebound. Although the specimen collection schedule was not designed to assess indinavir exposure, evaluation of random samples for indinavir levels suggested that patients taking triple-drug therapy that was failing had more dose interruptions than the indinavir maintenance group (data not shown). Brief periods of low or undetectable drug levels may have allowed unabated replication and the fitness disadvantage of early indinavir-resistant mutant virus may have allowed sensitive virus to predominate for months.

In terms of alternative hypotheses to explain outgrowth of virus wild type in protease with indinavir, the presence of p7/p1 or p1/p6 gag cleavage-sites mutations were ruled out by the sequencing, which also excluded the theoretical possibility of a gag-pol frameshift mutation resulting in increased expression of protease. Also, drug efflux transporters could have diminished indinavir’s effect and not been detected via measure of indinavir levels. This possibility is supported by the recent recognition of P glycoprotein transporters that can serve as protease efflux pumps in vitro.36,37

Our findings have several clinical implications. First, in patients failing suppressive antiretroviral combination regimens, the predominant virus population may be resistant to 1 (ie, lamivudine), but not all (ie, PI) components of the regimen. Second, not all drugs in a failing regimen (defined as a rebound in HIV RNA levels) may be lost options. Third, these data suggest that drug-resistance testing early after loss of suppression may be useful in identifying components of a failing regimen that might be useful in a new combination regimen. These results suggest value in assessing strategies using drug components of a failing combination evaluated by resistance testing.
However, systematic studies are needed to address concerns that retaining part of a regimen that appears sensitive on resistance testing could lead to selection of resistant minority species that may contribute to virologic failure of the new regimen and reduced treatment options. Finally, it must be acknowledged that PI-sensitive virus in patients taking a failing regimen is not necessarily evidence of nonadherence.

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REFERENCES


