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High-Density Lipoprotein Cholesterol in HIV-Infected Patients: Evidence for an Association with HIV-1 Viral Load, Antiretroviral Therapy Status, and Regimen Composition

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Abstract

Low high-density lipoprotein-cholesterol (HDL-C) levels have been associated with cardiovascular risk in non-HIV populations. Limited information exists on the prevalence of low HDL-C in HIV- infected patients and related factors remain largely unknown. The aims of this study were to estimate the prevalence and characteristics of low HDL-C levels in HIV-infected patients. A cross-sectional study was performed in consecutive HIV-infected patients cared for in an outpatient HIV clinic on the Mediterranean coast of Spain during a 2-month period (September 15, 2003 to November 15, 2003). HDL-C levels below 40 mg/dL were considered low. We analyzed data from 219 patients, 167 of whom were on antiretroviral therapy. The majority (45.20 %) were on non-nucleoside reverse transcriptase inhibitors (NNRTI); 22.83 % were on treatment with protease inhibitors. The prevalence of low HDL-C levels was 44.74 % (98 of 219 patients). In multivariate analysis, hypertriglyceridemia (triglycerides >150 mg/dL; odds ratio [OR], 5.65; 95% confidence interval [CI], 2.85–11.23; $p = 0.0001$), HIV-1 RNA viral load greater than 50 copies per milliliter (OR, 3.15; 95% CI, 1.63–6.109; $p = 0.001$) and antiretroviral therapy with regimens other than NNRTIs-based regimens (OR, 2.17; 95% CI, 1.12–4.16; $p = 0.021$) were associated with low HDL-C levels. These data indicate that prevalence of low HDL-C among HIV-infected patients from this cohort was very high. Low HDL-C was related to triglyceride levels, HIV-1 RNA viral load and antiretroviral therapy composition. Undetectable viral load and treatment with NNRTIs are protective factors, whereas hypertriglyceridemia is directly associated with low HDL-C levels.

Introduction

THERE IS AN INCREASING AWARENESS that cardiovascular disease (CVD) is augmented in HIV-infected patients.[1,2] Factors associated with HIV infection and antiretroviral therapy (ART) have been implicated in the premature development of atherosclerosis and coronary heart disease.[1,3,4]

Antiretroviral therapy can cause severe dyslipemia, characterized by an increase in the levels of total cholesterol, low-density lipoprotein cholesterol (LDL-C), and triglycerides, and a little increase or no change in high-density lipoprotein cholesterol (HDL-C) levels,[5] a proatherogenic lipoprotein profile associated with an increase in the incidence of cardiovascular disease.[6] Although the association between ART, especially regimens including protease inhibitors (PI), and the existence of significant changes in lipid and lipoprotein levels is well known,[7] most regimens tend to stabilize LDL-C and total cholesterol at levels similar to those before infection, whereas HDL-C levels usually remain low.[5]

HDL is a lipoprotein responsible for the efflux and transport back of cholesterol. Therefore, it plays an essential role in preventing atherosclerosis and cardiovascular events.[8] Indeed, a low HDL-C constitutes an independent risk factor for coronary heart disease in non-HIV population.[9] Current data about HDL-C in HIV-infected patients remain scarce. Although some reports have described that both HIV infection and ART can influence HDL-C levels,[10–12] none of the previous studies have focused on low HDL-C. The aim of this study was to estimate the prevalence of low HDL-C levels and to determine the associated factors in a clinical cohort of HIV-infected patients from the Mediterranean coast of Spain.

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Patients And Methods

Study population

A cross-sectional study was conducted at the HIV clinic of the university hospital of Elche, Spain. All consecutive HIV-infected patients attended during a 2-month period were included. Patients were 18 years of age or older, with no other inclusion–exclusion criteria. The study was approved by the local Ethics Committee. All subjects were informed about the study and gave their written consent before participation.

Clinical and laboratory evaluations

Clinical data including demographic characteristics, cardiovascular risk factors, anthropometric parameters (weight, height, waist and hip circumferences, and body mass index) and current antiretroviral regimen were obtained at the visit. Laboratory workup included C reactive protein (CRP) levels, fasting lipid levels, CD4 T-lymphocyte counts, plasma HIV-1 RNA, and routine safety blood tests. C reactive protein was measured by an immunoturbidimetric assay on a Hitachi 717 automated analyzer (Tina-quant CRP detection method, Roche Diagnostics, Mannheim, Germany; detection limit 0.003 mg/dL, between-assay coefficient of variance 3.62%, intra-assay variation 1.09%). Total and HDL cholesterol were measured by spectrophotometry (assays kits OSR 6216 and OSR 6187, respectively; Olympus Diagnostic, Lismeehan, O'Callaghan's Mills, Ireland; Palex Medical, Barcelona, Spain). LDL-C was estimated from quantitative measurements of total and HDL-cholesterol and plasma triglycerides using the empirical relationship of Friedewald and colleagues (1972). No calculation of LDL-C was performed in patients with triglyceride levels above 400 mg/dL. Plasma HIV-1 RNA viral load was measured using the Roche Amplicor Version 1.5 (Roche Diagnostics, Madrid, Spain; lower limit of detection 50 copies per milliliter plasma). The rest of the laboratory evaluations were measured using standard techniques.

Low HDL-C levels were defined as less than 40 mg/dL (1.04 mmol/L)[8] and hypertriglycercidemia as more than 150 mg/dL (1.69 mmol/L).[8] Patients were classified as hypertensive or diabetic if they had been previously diagnosed with hypertension or diabetes, or if they were on medical treatment for those disorders.

Statistical analysis

Descriptive statistics were computed by standard methods. To evaluate factors associated with low HDL-C concentrations, demographic, clinical, and laboratory variables, and treatment status were analyzed. To investigate the association of low HDL-C levels with current ART, only patients receiving the same ART regimen during the previous 3 months were included. Treatment was considered interrupted when the patient had discontinued all antiretroviral drugs for at least 3 months. In those patients with a shorter interruption, ART-related variables were not included in the analysis. We used Spearman's correlation coefficient to determine the association between levels of HDL-C and continuous variables. To compare HDL-C levels according to categorical variables, we applied the Mann-Whitney test or Kruskal Wallis test when appropriate. In a second phase of the analysis, HDL-C was dichotomized into less than 40 and 40 mg/dL or more categories, and levels below 40 mg/dL were considered low. We also categorized HIV related continuous variables under study as follows: HIV viral load (<50 and ≥ 50 copies/mL) and HIV infection transmission category (injection drug users versus others).

The association of low HDL-C with HIV-related variables, ART and other cardiovascular risk factors was examined by univariate analysis. Multivariable analyses were carried out including all variables of univariate analysis, although not statistically significant. Logistic regression models were used to obtain an adjusted measure of the effect of HIV related variables and ART on the risk of low HDL-C levels, controlling for more than one confounder simultaneously. A p value of < 0.05 was considered to be statistically significant. Statistical analyses were performed using SPSS, version 12.0 (Chicago, IL).

Results

Demographic and clinical characteristics of the 219 patients included are shown in Table 1. Mean (standard deviation [SD]) age was 42 years (10 years) and 79% were males. There was a high rate of smokers (72.14%) and median lifetime tobacco exposure was 20 (18) pack-years. HIV-infection was acquired by intravenous drug use in 52.5% of patients. One hundred sixty-seven (76.25%) were on ART, 45.2% were receiving non-nucleoside reverse transcriptase inhibitor (NNRTI)–based regimens, and 22.83% PI-based regimens. Fifty-seven percent of the patients had been previously exposed to PIs.

Mean (SD) HDL-C among the 219 patients was 43.42 (14.14) mg/dL. HDL-C correlated positively with age ($r = 0.163$; $p = 0.016$), and negatively with HIV viral load ($r = -0.341$; $p < 0.0001$), triglycerides ($r = -0.316$; $p < 0.001$), and C-reactive protein (CRP) levels ($r = -0.142$; $p = 0.036$; Table 2). Concentrations were significantly higher in patients with undetectable viral load ($p < 0.001$), lower in patients with family history of cardiovascular disease ($p < 0.001$), and tended to be lower in males ($p = 0.064$) and in smokers ($p = 0.074$). The relationship of HDL-C and antiretroviral therapy (ART) is also shown in Table 2. Patients who were not receiving ART exhibited significantly lower HDL-C levels than treated patients (median [interquartile range {IQR}], 34.9 [28.7, 44.6] mg/dL versus 43.1 [35.6, 52.85] mg/dL, $p < 0.0001$). Among patients not receiving ART, HDL-C levels were significantly lower in those who had discontinued ART than in naïve patients (median [IQR], 34.3 [27.1,43.25] mg/dL versus 37 [30.65,49.17] mg/dL, $p = 0.046$). When the three antiretroviral classes were compared, HDL-C levels were highest among patients on NNRTI, and lowest among those on NRTI (χ^2 7.38; $p = 0.025$). Nevirapine was the single antiretroviral associated with the highest HDL-C levels (52.34 [16.9] mg/dl, $p < 0.001$ for the comparison with patients not receiving nevirapine). In patients receiving efavirenz, mean (SD) HDL-C was 44.94 (10.9) mg/dL, $p = 0.022$ for the comparison with patients not receiving efavirenz.

Levels of HDL-C were below reference values ($<$ 40 mg/dl) in 98 (44.74%) patients. Factors associated with low HDL-C levels by univariate analysis are shown in Table 3. Comparing participants with low HDL-C levels with those with normal/high HDL-C leveles, first-degree family history

Table 1. Demographic and Clinical Characteristics of the Two Hundred Nineteen HIV-Infected Patients

Characteristic	*Value*
Age, years	42 (10)
Gender, male, no. (%)	173 (79)
HIV intravenous drug user, no. (%)	115 (52.5)
CDC category (%)	
A	139 (63.4)
B	24 (10.9)
C	56 (25.5)
Current antiretroviral therapy, no. (%)	167 (76.25)
Protease inhibitors	50 (22.83)
NNRTI-based regimen	99 (45.2)
NRTI-based regimen	18 (8.21)
Without treatment (%)	
Naive (%)	24 (11)
Treatment stopped (%)	28 (11.42)
Previous PI exposure (%)	125 (57)
Time of exposure to antiretroviral therapy, years	4.18 (3)
HIV-RNA viral load < 50 copies/mL, no. (%)	121 (55.25)
$CD4^+$ cell count, cell/mm^3	532 (292)
Hepatitis C virus coinfection, no. (%)	97 (44.29)
Current smokers, no. (%)	158 (72.14)
Body mass index, kg/m^2	24.54 (4.19)
Systolic blood pressure (mm Hg)	110.87 (16.93)
Diastolic blood pressure (mm Hg)	66.99 (9.74)
Triglycerides (≥ 150 mg/dL) (%)	75 (34.2)
Low HDL-C levels,[a] no. (%)	98 (44.74)
Total cholesterol (mg/dL)	176.98 (43.39)
LDL cholesterol (mg/dL)	107.25 (36.55)
Lipodystrophy (%)	86 (39.26)
Type 2 diabetes mellitus, no. (%)	15 (6.8)
Hypertension, no. (%)	20 (9.13)
Framingham Score:	
Low risk	170 (77.6)
Moderate risk	44 (20)
High risk	5 (2.28)

[a]HDL cholesterol < 40 mg/dL (1.04 mmol/L)

All numeric variables are presented as means (SD) and no. (%) of patients.

NNRTI, non-nucleoside reverse transcriptase inhibitor; PI, protease inhibitor; NRTI, nucleoside reverse-transcriptase inhibitor; CDC, Centers for Disease Control.

Cardiovascular Risk by According to Framingham (<10% low risk, 10%–20% moderate risk and 20%, high risk).

of cardiovascular event (28.5% versus 12.39%; $p = 0.002$), higher CRP levels (mean [SD], 0.53 [0.74] ng/dL versus 0.33 [0.47] ng/dL; $p = 0.029$), hepatitis C virus coinfection (51% versus 38.84%; $p = 0.045$), hypertriglyceridemia (>150 mg/dL; 51% versus 20.6%; $p < 0.001$), not receiving ART (being untreated; 33.67% versus 15.7%, $p = 0.002$), and ART interruption (20.4% versus 7.4%, $p = 0.003$) were associated with low HDL-C levels. An undetectable viral load (39.79% versus 67.7%; $p = 0.0001$), and ART including NNRTI (32.65% versus 55.37%; $p = 0.001$) were inversely associated with low HDL-C levels.

Forward logistic regression analysis was performed to identify predictors of low HDL-C levels. The following variables were included: treatment with PI vs any other or no therapy, treatment with NNRTI versus any other or no therapy, treatment with NRTI versus any other or no therapy, treatment off, HIV-RNA viral load above 50 copies per milliliter, triglyceride levels, age, LDL-C levels, and first-degree family history of cardiovascular events. An HIV-RNA viral load above 50 copies per milliliter (odds ratio [OR], 2.8; 95% confidence interval [CI], 1.38–5.76; $p = 0.005$), and hypertriglyceridemia (>150 mg/dL; OR 5.28; 95% CI, 2.51–11.11; $p = 0.001$) were associated with low HDL concentrations. ART including NNRTI (OR 2.24; 95% CI, 1.1–4.56; $p = 0.025$) was a protective factor against low HDL-C levels.

Table 4 shows how the association between NNRTI and low HDL-C levels of univariate analysis ("crude" model) changes when adjusted for the other significant variables, specially for viral load, from higher to lesser protection against low HDL-C levels.

Discussion

The prevalence of low HDL levels in HIV-infected subjects from this Mediterranean cohort was high. Patients not

Table 2. Relationship of HDL-C with HIV-Related Variables and Cardiovascular Risk Factors

Variable	*HDL-C concentration, median (IQR) (mg/dL)*	*Spearman's correlation coefficient*	p
Age		0.163	0.016
Serum LDL cholesterol level		0.247	0.000
Serum Tryglicerides level		−0.316	0.000
C-reactive protein		−0.142	0.036
Body mass index		−0.023	0.740
Plasma HIV-1 RNA copies/mL[a]		−0.341	0.000
$CD4^+$ cell count		0.1	0.142
First-degree family history of cardiovascular events.			
Yes	35.8 (31.7, 46.8)		0.005
No	43.1 (34.9, 52.55)		
Gender			
Female	45.25 (35.7, 56.1)		
Male	40.8 (33.45, 49.8)		0.064
Cigarette smoking			
Yes	40.8 (33.47, 49.8)		
No	45.25 (34.97, 54.15)		0.074
Hypertension			
Yes	38.9 (31.85, 58.05)		
No	41.6 (33.9, 50.6)		0.576
Diabetes mellitus			
Yes	35 (30.4, 48.6)		
No	41.8 (34, 40.9)		0.345
Risk factor for HIV-infection			
Intravenous drug user	40.4 (32.5, 49.4)		
Other	43 (35.2, 52.1)		0.107
Plasma HIV-1 RNA $<$ 50 copies/mL	46.1 (37.9, 55.1)		
Plasma HIV-1 RNA $\geq$ 50 copies/mL	37 (30.5, 44.3)		0.000
On ART	43.1 (35.6, 52.85)		$<$0.0001[b]
On NNRTIs	46.8 (38.6, 55.4)		0.025[c]
On PIs	41.5 (34.3, 51.2)		
NRTIs	39.65 (33.67, 45.9)		
Off ART	34.9 (28.7, 44.6)		
Naive[d]	37 (30.65, 49.17)		0.046
Discontinued	34.3 (27.1, 43.25)		

[a]Only patients with HIV-1 RNA $\geq$ 50 copies/ml, $n = 121$ patients.
[b]p value for the comparison for patients on ART vs. patients off ART (Mann-Whitney test).
[c]p value for the comparison among the three classes of antiretroviral regimens (Kruskal Wallis test).
[d]p value for the comparison with patients who had discontinued ART (Mann-Whitney test).

receiving ART had markedly lower levels of HDL-C than treated patients, especially those who had previously discontinued the ART, who exhibited the lowest HDL-C levels. Protective factors against low HDL-C were an undetectable viral load and receiving an antiretroviral regimen including NNRTIs.

Prevalence of low HDL-C in general population varies depending on several factors, including age, gender, comorbidity, dietary, and ethnic or geographic factors, ranging from 7%–9%[13,14] in France to 17%–38% in the United States.[15,16] In a large study carried out in Spain that included working people with a mean age of 36.4 years (range, 16–74), 73.1% of them male, the prevalence of low HDL-C was 25.6% (95% CI, 25.4%–25.7%).[17] Thus, the prevalence of low HDL-C in our cohort nearly doubled that of a general Spanish population of similar characteristics. Available data about prevalence of low HDL-C in HIV-infected patients have been mainly obtained from cohort studies evaluating metabolic syndrome, in which a high prevalence of low HDL-C has also been described. In a study carried out in HIV-infected patients from the Nutrition for Healthy Living (NFHL) cohort in the United States to evaluate the incidence of metabolic syndrome, the prevalence of low HDL levels ($<$ 40 mg/dL for men and $<$ 50 mg/dL for women) was 54% (95% CI, 49%–58%).[18] The adjusted (age, gender, race, poverty, exercise, and diet) OR for low HDL-C compared to general population was 2.7 (95% CI, 1.7–4.3) for patients not receiving ART users and 1.6 (95% CI, 1.1–2.1) for those on ART. In a recent transversal study about metabolic syndrome carried out on the Mediterranean coast of Spain,[19] 33.9% of the HIV-infected men had HDL levels below 40 mg/dL, and 40.2% of the women had levels below 50 mg/dL. In agreement with a recent study,[20] most of our patients belonged to a low-risk Framingham category, and had frequently low HDL-C in spite of this.

Table 3. Univariate Analysis of Clinical Variables and Low HDL-C (<40 mg/dl) Levels

	Patients with HDL-C levels <40 mg/dl (n = 98)	*Patients with HDL-C levels ≧40 mg/dl (n = 121)*	P
Age (years)	41.16 (8.57)	42.71 (11.06)	0.259
Sex (%)			
Male	81 (82.65)	92 (76)	
Female	17 (17.3)	29 (23.9)	0.232
First-degree family history of cardiovascular events	28 (28.5)	15 (12.39)	0.002
Body mass index (kg/m^2)	24.63 (3.90)	24.47 (4.43)	0.79
HIV transmission (%)			
Intravenous drug users	56 (57.14)	60 (49.58)	
Others	42 (42.86)	61 (50.4)	0.241
C-reactive protein concentration, mg/dl	0.53 (0.74)	0.33 (0.47)	0.029
CD4$^+$ cell count, cells/mm^3	494 (278.86)	563.47 (301.4)	0.079
RNA-HIV viral load < 50 copies/mL (%)	39 (39.79)	82 (67.7)	0.000
Hepatitis C virus coinfection (%)	50 (51)	47 (38.84)	0.045
Current smokers (%)	73 (74.48)	84 (69.42)	0.227
Lipodystrophy (%)	35 (35.7)	51 (42.14)	0.275
Hypertriglyceridemia (>150 mg/dl) (%)	50 (51)	25 (20.6)	0.000
Time of exposure to antiretroviral therapy, years	4.34 (3.4)	4.05 (2.71)	0.407
Previous exposure to protease inhibitors	58 (59.18)	69 (57)	0.203
Current antiretroviral therapy, no. (%)	65 (66.32)	102 (84.29)	0.002
PI (%)	24 (24.48)	26 (21.48)	0.692
NNRTI-based regimen (%)[a]	32 (32.65)	67 (55.37)	0.001
NRTI-based regimen (%)	9 (9.18)	9 (7.4)	0.591
No treatment	33 (33.67)	19 (15.7)	0.002
Therapeutic interruption (%)	20 (20.4)	9 (7.4)	0.003
Naive (%)	13 (13.26)	11 (9)	0.321

[a]22.6% of patients receiving nevirapine had low HDL-C levels compared to 58.1% of those not on nevirapine ($p = 0.0001$). 40.7% of the patients receiving efavirenz had low HDL-C ($p = 0.03$ for the comparison with those not receiving efavirenz).

All numeric variables are presented as means (SD) and no (%) of patients.

NNRTI, non-nucleoside reverse-transcriptase inhibitor; PI, protease inhibitor; NRTI, nucleoside reverse-transcriptase inhibitor. CDC, Centers for Disease Control and Prevention.

In our study a suppressed HIV viral load was a protective factor against low HDL-C levels. Consistent with this finding, we found a negative correlation between viral load and HDL-C, an observation also noticed in other studies and, noteworthy, even in naïve patients.[10,21] Rose et al.[10] found a negative correlation of HDL-C levels with current and peak viral load, and a positive one with current and nadir CD4 cell count, suggesting that HIV infection itself, rather than ART, was implicated in the low HDL-C levels of HIV-infected patients. The correlation remained significant in patients receiving PI-based or efavirenz-based regimens. The authors concluded that HDL-C levels were reduced proportionally to the severity of HIV infection, with type of ART having a limited impact.[10] These data are consistent with the significant association between HDL-C and time of undetectable viral load found in other study,[22] and with the lower levels of HDL-C of nontreated patients compared with those on ART described herein and previously.[5,10,23]

According to the results of previous studies, a significant contribution to the low HDL-C levels of HIV-untreated patients is that of subjects who had interrupted their ART, since all untreated patients had received prior ART for an aver-

Table 4. Logistic Regression Models for the Effect of NNRTI on the Low HDL-C Levels

Model	*OR (95% CI)*	p[a]
Model 1: Crude	0.388 (0.223–0.676)	0.001
Model 2: Model 1 + Triglycerides	0.339 (0.185–0.621)	0.000
Model 3: Model 2 + Plasma HIV-1-RNA > 50 copies/ml	0.463 (0.24–0.878)	0.018
Model 4: Model 1 + Plasma HIV-1-RNA > 50 copies/ml	0.518 (0.287–0.934)	0.029

[a]*p* Value based on the Wald test.

NNRTI, non-nucleoside reverse-transcriptase inhibitor; HDL-C, high-density lipoprotein C.

age of 3.6 years in one study,[10] or the proportion of pretreated patients was of 54% in another.[23] In our study, patients who had discontinued ART had a significantly lower HDL-C than naïve patients in univariate analysis, although the association did not remain in multivariate analysis. A study recently reported by the AIDS Clinical Trials Group (ACTG) researchers[24] describes a marked decrease in HDL-C in patients who discontinued ART. Authors hypothesize that this could partially explain the increase of cardiovascular events observed in the SMART trial and other studies after the discontinuation of antiretroviral therapy. Low HDL-C is a well-recognized independent risk factor for adverse cardiovascular outcomes, irrespective of the levels of LDL-C.[8,25] The higher cardiovascular risk associated with low HDL-C levels is also supported by the negative correlation between HDL-C and CRP levels observed in our patients and in earlier reports.[3,26] Of note, in a previous study evaluating oxidative stress in this cohort of patients, it also tended to be higher in patients not receiving ART, and patients who had interrupted ART showed the highest levels of all groups.[27]

An additional protective factor against low HDL-C was an antiretroviral regimen including NNRTI. Nevirapine has been associated with a striking increase of HDL-C in naïve[11] as well as in PI-exposed patients.[12] In our study, significantly higher HDL-C levels were found in patients receiving versus those not receiving nevirapine. Nevirapine-based antiretroviral regimens were also protective against oxidative stress in this cohort.[27] We found no different levels of HDL-C in users versus nonusers of efavirenz, although the frequency of low HDL-C levels in patients receiving efavirenz was significantly lower. Previous studies have also found higher increases in HDL-C with nevirapine than with efavirenz containing regimens.[28,29] Conversely to the NNRTIs-including regimens, in our study no significant differences in the HDL-C levels were found between untreated patients and those on PI-containing regimens, although most patients were on regimens including NNRTIs. An absence of significant changes in HDL-C values has also been described in patients receiving PIs compared with nontreated patients,[5,30] as well as significantly lower mean HDL-C levels with PI- versus non-PI–containing regimens.[23] There is a well-established inverse association between fasting triglycerides and HDL-C concentrations.[31,32] In hypertriglyceridemic patients, low HDL-C levels is commonly believed to be linked to the derangement of triglyceride metabolism. Accordingly, an increase in HDL-C concentrations has been described in patients under dietary or pharmacologic therapy for hypertriglyceridemia.[31] The rise in triglyceride levels linked to therapy with PIs might be one of the mechanisms implicated in the lower HDL-C levels of these patients compared to patients receiving NNRTIs. The association of low HDL-C levels with hepatitis C virus (HCV) coinfection had not been reported in previous studies. A reduction in LDL[33] and total cholesterol levels,[34] especially the latter, in the final stages of liver disease, has been described, but, to our knowledge, HDL-C had not been implicated in the lipidic changes accompanying HCV infection. However, these results must be interpreted with caution given the transversal nature of the study and the fact that the last association was only found in univariate analysis.

Some study limitations should be acknowledged. First, its transversal nature means that the associations found can not be classified as causal. Second, the number of patients included was not high, that limiting the power and accuracy of the analyses. The study benefits from enrolling both patients receiving ART and subjects with no therapy, including those with treatment interruptions.

In summary, our results indicate that a high proportion of HIV-infected patients have low HDL-C concentrations, and support an association of HDL-C levels with HIV-1 viral load, and ART status and composition. Attention should be paid to patients discontinuing antiretroviral therapy, since a higher frequency of low HDL-C levels might be encountered, that could implicate a higher risk of future cardiovascular events.

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