Title
Associations between lipids and subclinical coronary atherosclerosis

Journal
AIDS, Publish Ahead of Print(&NA;)

ISSN
0269-9370

Authors
Whelton, Seamus P
Deal, Jennifer A
Zikusoka, Michelle
et al.

Publication Date
2019-05-01

DOI
10.1097/qad.0000000000002151

Peer reviewed

HHS Public Access

Author manuscript

AIDS. Author manuscript; available in PMC 2020 May 01.

Published in final edited form as:

AIDS. 2019 May 01; 33(6): 1053–1061. doi:10.1097/QAD.0000000000002151.

Associations between lipids and subclinical coronary atherosclerosis

Seamus P. Whelton[#a], **Jennifer A. Deal**[#b], **Michelle Zikusoka**[#c], **Lisa P. Jacobson**[b], **Sudipa Sarkar**[d], **Frank J. Palella Jr.**[e], **Lawrence Kingsley**[f], **Matthew Budoff**[g], **Mallory D. Witt**[g], **Todd T. Brown**[d], and **Wendy S. Post**[a,b]

[a)]Ciccarone Center for the Prevention of Cardiovascular Disease, Division of Cardiology, Department of Medicine, Johns Hopkins University School of Medicine. 600 North Wolfe Street, Baltimore, MD 21287

[b)]Department of Epidemiology, Johns Hopkins Bloomberg School of Public Health 2024 E. Monument St, Suite 2-700, Baltimore, MD 21205

[c)]MedStar Health System, 5601 Lock Raven Boulevard, Baltimore, MD 21239

[d)]Division of Endocrinology, Department of Medicine, Johns Hopkins University School of Medicine. 600 North Wolfe Street, Baltimore, MD 21287

[e)]Division of Infectious Diseases, Feinberg School of Medicine of Northwestern University. 645 N. Michigan Ave, Chicago, IL 60611

[f)]Department of Infectious Diseases and Microbiology, University of Pittsburgh Graduate School of Public Health. 130 De Soto Street, Pittsburgh, PA 15261

[g)]Division of HIV Medicine, Los Angeles Biomedical Research Institute at Harbor UCLA Medical Center. 1124 West Carson St. Torrance, CA 90502

[#] These authors contributed equally to this work.

Abstract

Objective: Whether HIV modifies the relationship of serum lipids with coronary atherosclerosis and coronary plaque subtypes is uncertain. We examined the associations between traditional lipids and coronary atherosclerosis among HIV-infected (HIV+) and HIV-uninfected (HIV−) men.

Design: The Multicenter AIDS Cohort Study (MACS) is an observational cohort with a total of 429 HIV+ and 303 HIV− men who had non-contrast cardiac computed tomography (CT) performed to measure coronary artery calcium (CAC) and coronary CT angiography to measure coronary stenosis, coronary plaque presence, and composition.

Methods: We used multivariable adjusted prevalence ratios (PR) to examine the relationship between the standard deviation (SD) difference in each lipid parameter and coronary atherosclerosis.

Corresponding author: Seamus P. Whelton, MD, MPH, Johns Hopkins University School of Medicine, Ciccarone Center for the Prevention of Cardiovascular Disease, 600 North Wolfe Street, Blalock 524A, Baltimore, MD 21287, seamus.whelton@jhmi.edu.

Results: Total cholesterol (TC) / HDL-C had the strongest associations with coronary atherosclerosis regardless of HIV status. Overall, lipid parameters were most strongly associated with the presence of mixed plaque, stenosis >50%, and CAC for both HIV+ and HIV− men. HIV+ men had similar, but weaker associations, between lipid parameters and coronary atherosclerosis compared to HIV− men. The strongest association was between the TC/HDL-C and stenosis >50% for both HIV+ [PR 1.25 per SD (95% CI 1.07–1.43)] and HIV− men [PR 1.46 per SD (95% CI 1.08–1.85)].

Conclusion: The associations between lipids and coronary atherosclerosis tended to be weaker for HIV+ compared to HIV− men, although TC/HDL had the strongest association for both HIV+ and HIV− men. A weaker association between lipid levels and coronary atherosclerosis for HIV+ men may contribute to the decreased discrimination of CVD risk observed in HIV+ individuals.

Keywords

Lipids; HIV; coronary artery disease; atherosclerosis

Introduction

Human immunodeficiency virus (HIV) infected individuals have an estimated 40–75% increased risk for atherosclerotic cardiovascular disease (ASCVD), a leading cause of death for HIV+ individuals receiving highly active antiretroviral therapies (HAART) in the United States.[1–3] The pathophysiology for this increased rate of ASCVD is multifactorial and includes heightened inflammation and immune dysregulation, an increased prevalence of ASCVD risk factors, coagulation disorders, and impaired endothelial function.[4–9] There may also be differences in the pathophysiology of atherosclerosis for HIV-infected (HIV+) individuals and we, and others, have previously demonstrated that HIV+ men have a higher prevalence of non-calcified plaque compared to HIV− men.[10, 11]

Treatment with older HAART regimens is associated with an increase in total cholesterol (TC) and low-density lipoprotein (LDL) cholesterol, which is also known as the “return to health” phenomenon.[12, 13] Use of some protease inhibitors in particular are also associated with an increase in triglycerides and first generation protease inhibitors have also been suggested to increase the risk for CVD.[14] This increase in lipid levels with HAART may be due to decreased inflammation, associated improved virologic control and potentially represent an individual’s pre-HIV infection lipid baseline. Accordingly, these lipid changes make accurate ASCVD risk assessment more difficult and the 2013 American College of Cardiology (ACC)/American Heart Association (AHA) Pooled Cohort Equation (PCE) underestimates the ASCVD risk among individuals with HIV infection and acquired immunodeficiency syndrome (AIDS).[15–18]

Coronary CT angiography provides a detailed assessment of the coronary anatomy for both coronary stenosis and plaque composition. Therefore, a detailed description of the relationship between traditional lipid values and coronary atherosclerosis is imperative to better understand potential differences in the pathophysiology of coronary atherosclerosis for HIV+ individuals and to improve ASCVD risk prediction. We used data from the Multicenter AIDS Cohort Study (MACS), which included a detailed assessment of the

coronary anatomy for both coronary stenosis and plaque composition using coronary computed tomography (CT) angiography in order 1) to determine associations between lipid levels and various components of coronary atherosclerotic plaque composition and 2) to examine whether the relationship between traditional lipid values and subclinical coronary atherosclerosis differs by HIV serostatus and.

Methods

MACS is a cohort study comprised of HIV+ and HIV− bi-sexual and homosexual men who are at risk for HIV infection. Participants were initially enrolled from 1984–1985 in Baltimore, Maryland/Washington, DC; Chicago, Illinois; Pittsburgh, Pennsylvania; and Los Angeles, California with subsequent enrollment occurring between 1987 to 1991 and 2001 to 2003.[19] Semi-annual visits include standardized interviews, physical examination, and collection of blood. Participants in the MACS cardiovascular ancillary study were between 40 to 70 years of age, weighed less than 300 pounds, had no prior history of cardiac surgery or percutaneous coronary intervention, or current atrial fibrillation, and were oversampled for HIV+ men. Participants were excluded from coronary CT angiography if they had chronic kidney disease (estimated glomerular filtration rate <60 mL/min/1.73 m^2) or a known history of intravenous contrast allergy. The current analysis included 732 men who underwent coronary CT angiography after excluding men with missing fasting lipid data (n=27). The study was approved by the institutional review boards of all participating sites and participants provided informed consent.

The computed tomography (CT) non-contrast and contrast scan protocols used in this study have been previously described in detail and the CT angiogram scans were performed between January 2010 and June 2013.[20] Three centers used 64-slice multi-detector CT and one center used 320-row multi-detector CT. The coronary artery calcium (CAC) score was calculated using the Agatston method and in this analysis was classified as either absent (CAC <10) or present (CAC ≥10).[21]. A prospective EKG triggered protocol was used for CT angiography (CTA) studies to minimize radiation exposure, except in cases where the heart rate was too fast or irregular.The median radiation dose for the CTA scans was 2.0 mSV (interquartile range 1.7–2.9).

CT images were transferred to the core CT center (Los Angeles Biomedical Research Institute at Harbor-UCLA) and interpreted by experienced readers who were blinded to participant characteristics and HIV serostatus. For CTA studies each coronary segment was analyzed using the modified 15-segment model of the AHA. Any object identified in at least two independent planes that was a part of the coronary artery vessel wall with a CT density less than the contrast-enhanced lumen, but greater than the surrounding connective tissue was defined as a non-calcified atherosclerotic plaque. If the object had an attenuation ≥130 Hounsfield Units (HU), it was defined as a calcified atherosclerotic plaque. The presence of coronary plaque along with its associated size, composition (calcified, non-calcified, or mixed), and degree of luminal narrowing were evaluated using axial images, multi-planar reconstructions, and maximum intensity projections in all assessable coronary segments. If there was calcium that occupied <50% of the plaque area it was defined as mixed.

Participants were seen every six months as part of routine MACS research visits. Data were collected regarding ASCVD risk factors and HIV clinical parameters by self-reported history, physical examination, and blood tests. For this analysis, the data used were collected at the MACS study visit closest to the CT scan, which was approximately within 6 months of the CT scan. Data collected included demographics and clinical parameters including age, self-reported race/ethnicity (Caucasian, African-American, and Hispanic and Other), study center, body mass index (BMI), and systolic blood pressure (SBP). Self-reported data included smoking status (former, never, current), cumulative pack-years, initiation of HAART, duration of HAART therapy, and use of medications to treat hypertension, dyslipidemia, and diabetes.

Fasting serum samples were collected on the day of the CT scan or within approximately 6 months of the CT scan at the routine MACS study visit [average time between blood draw and CT scan was 1.4 months (standard deviation (SD) ±2.2)]. Total cholesterol was measured using an enzymatic method and high density lipoprotein (HDL) cholesterol was measured using selective precipitation with removal by centrifugation of LDL-C at the Heinz laboratory, University of Pittsburgh.[22, 23] LDL-C was calculated using the Friedewald equation except for men with triglycerides >400 mg/dL in whom it was measured directly.[24] Non-HDL-C was calculated by subtracting HDL-C from the TC and the TC/HDL-C ratio was calculated by dividing the TC by HDL-C. Triglyceride levels were log transformed for this analysis due to their non-normal distribution.

Distributions of demographic and clinical factors by HIV serostatus were compared using Student's t-test, Wilcoxon rank-sum test, or chi-square test as appropriate. Poisson regression with robust variance was used to estimate prevalence ratios (PR) and 95% confidence intervals for coronary plaque outcomes per standard deviation increase in lipid parameters. In order to test whether the association between the lipid parameters and plaque outcomes differed by HIV serostatus, we included an interaction term between HIV and each lipid parameter. Similarly, we tested for a statistical interaction between lipid lowering medications and each lipid parameter.

We calculated progressively adjusted PR models with Model 1 including age, race, study site, and HIV serostatus. Model 2 additionally included body mass index (BMI), systolic blood pressure (SBP), use of antihypertensive, diabetes, or lipid-lowering medication use along with fasting glucose and smoking status. Missing covariate data were imputed using multiple imputation; imputation models included all predictor variables and the outcome and were imputed 5 times based on Markov-chain Monte Carlo method.[25] Continuous covariates were centered at a clinically relevant value (BMI, SBP, fasting glucose), or at the mean of the distribution (age, HIV clinical parameters). Statistical analysis was performed using Stata Version 13.1 (StataCorp. 2013. *Stata Statistical Software: Release 13*. College Station, TX: StataCorp LP).

Results

HIV+ men were younger, more likely to be black and be a current smoker, and had a lower BMI. TC, LDL-C, and HDL-C levels were lower, and triglycerides and TC/HDL-C ratio

were higher in HIV+ compared to HIV− men (Table 1). There was no difference in non-HDL-C between HIV+ and HIV− men. HIV+ men with a detectable viral load had lower mean TC (178.2 ± SD 40.0 mg/dl vs. 187.5 ± SD 40.6 mg/dl, p= 0.04) and non-HDL-C (129.8 ± SD 38.1 mg/dl vs. 139.0 ± SD 38.2, p=0.03) than men without detectable viral load (Supplemental Table 1). Lipid lowering medication was used by 33.6% of HIV+ men and 30.7% for HIV− men (p=0.56). Overall, HIV+ men had a higher prevalence of non-calcified plaque (63.2%) compared to HIV− men (53.1%), but there was no significant difference in the total proportion of men with any coronary plaque or calcified coronary plaque.

When evaluating associations between lipid parameters and atherosclerotic plaque, there was generally a positive relationship between atherogenic lipid parameters and the prevalence of atherosclerosis, while HDL-C was inversely associated with atherosclerosis (Figure 1). However, not all lipid parameters were statistically significantly associated with all coronary plaque measures. Non-HDL-C was significantly associated with a greater prevalence of all coronary plaque outcomes. In addition, the TC/HDL-C was significantly associated with a greater prevalence of all coronary outcomes except calcified plaques as measured by CTA (PR 1.04, 95% CI 0.95–1.14). Greater HDL-C level was only associated with a significantly lower prevalence of mixed plaque (PR 0.83, 0.74–0.93), CAC (PR 0.89, 0.82–0.97), and in particular stenosis >50% (PR 0.70, 0.57–0.85).

Overall, HIV+ men had similar, but generally attenuated associations between lipid levels and coronary plaque outcomes compared to HIV− participants (Figure 2), although the interaction tests by HIV serostatus were only significant for HDL-C and calcified plaque measured by CTA. The TC/HDL-C had the strongest observed association for coronary outcomes for both HIV+ and HIV – men and in particular its association with stenosis >50% was PR 1.25 (95% CI 1.07–1.43) for HIV+ men and PR 1.46 (95% CI 1.08–1.85) for HIV− men (Table 2). In general, for HIV+ men lipid parameters were most consistently associated with any plaque and non-calcified plaque, while for HIV− men they were most strongly associated with any plaque, stenosis >50%, and CAC. Among HIV+ men, the only significant association observed for LDL-C was with the presence of any plaque on CTA (PR 1.05, 1.00–1.09).

There were no statistically significant associations between lipid levels and the presence of calcified coronary plaques as measured by CTA for either HIV+ or HIV− participants, except that a higher TC/HDL-C was associated with a greater PR for CAC for both HIV+ (PR 1.10, 1.00–1.2) and HIV− (PR 1.17, 1.02–1.32) men. However, among men not taking lipid lowering medication, all lipid parameters were significantly associated with CAC (inversely for HDL-C), while none of the lipid parameters were associated with CAC for men taking a lipid lowering medication. In addition, there was a statistically significant interaction ($p<0.05$) between lipid lowering medication use and total cholesterol, triglycerides, non-HDL-C, and TC/HDL-C associations with CAC.

The associations between lipid parameters and coronary plaque were stronger for men not taking a lipid lowering medication compared to those taking lipid lowering medication (Table 3). There were no significant associations between lipid levels among men on lipid lowering therapy and the prevalence of any plaque, calcified plaque on CTA, or non-

calcified plaque. The strongest observed associations were among men not taking lipid lowering medication for TC/HDL-C and stenosis >50% with a PR of 1.39 (95% CI 1.13–1.65) and for triglycerides with a PR of 1.56 (95% CI 1.22–1.90). Men not taking lipid lowering medication had significantly stronger associations between many, but not all, atherogenic lipid parameters with prevalence of mixed plaque, stenosis >50%, and CAC compared to the associations seen among men on lipid lowering therapy (p for interaction <0.05). In particular, triglycerides were strongly associated with stenosis >50% (PR 1.56, 1.22–1.90) for men not taking lipid lowering medication, but there was no significant association for men taking lipid lowering medication (PR 1.17, 0.90–1.43). In addition, non-HDL-C levels were significantly associated with prevalence of CAC (PR 1.22, 1.08, 1.36) in men not taking lipid lowering medications but was not associated with CAC in men taking lipid lowering medications (PR 0.97, 0.86, 1.08, p interaction <0.05). Similar interactions by lipid lowering mediation use status were seen for other lipid parameters with CAC and for mixed plaque.

The results were similar when we examined HIV+ participants only and when stratified by both HIV serostatus and lipid lowering medication use (Supplemental Tables 2 and 3). The duration and control of HIV may also mediate lipid levels and the development of coronary atherosclerosis and we performed a subgroup analysis to examine the association between markers of HIV disease control and lipid levels that did not show a statistically significant consistent relationship by HIV specific parameters (Supplemental table 4).

Discussion

This analysis demonstrates that traditional lipid levels tended to have weaker associations with subclinical coronary atherosclerosis for HIV+ compared to HIV− men across all coronary plaque outcomes, although there was no consistent statistically significant interaction between HIV serostatus and any individual lipid parameter. The TC/HDL-C had the strongest association with subclinical coronary atherosclerosis, for both HIV+ and HIV−menand among the measures of coronary atherosclerosis, lipid parameters were most strongly associated with stenosis >50% for both HIV+ and HIV – men.

Traditional ASCVD risk assessment models such as the 2013 ACC/AHA Pooled Cohort Equation have a weaker association with coronary plaque burden and underestimate risk among HIV+ individuals compared to HIV− individuals, by as much as 20%. [17, 18] This underestimation among HIV+ individuals is likely secondary to a greater impact of non-traditional atherosclerotic risk factors that are not included in the equation, such as increased inflammation and impaired endothelial function.[26] However, the specific reasons for the underestimation of atherosclerotic risk among HIV+ individuals is incompletely understood.

This analysis is the first, to our knowledge, to examine the associations of traditional lipid parameters and subclinical coronary atherosclerosis in a cohort of HIV+ and HIV− men. Our study provides important information about the relationship of traditional lipids and coronary plaque composition, for which there also is limited information in non-HIV cohorts. The trends towards weaker observed associations of traditional serum lipid parameters and subclinical coronary atherosclerosis in HIV+ compared to HIV− men may

contribute to the underestimation of atherosclerotic risk among HIV+ individuals using traditional risk equations. Furthermore, it provides an approximation of the relative reduction in the associations between traditional lipid levels and subclinical coronary atherosclerosis for HIV+ men.

Statins appear to have a similar reduction in their LDL-C lowering efficacy among HIV+ and HIV− individuals.[27–29] However, the results of this analysis suggest that other non-traditional atherosclerotic risk factors, such as inflammation, HAART use, and hypercoagulability may have heightened importance in the development of atherosclerosis in HIV+ individuals. Indeed, the Data Collection on Adverse Effects on Anti-HIV drugs Cohort –DAD (DAD) risk score incorporates use of specific antiretroviral medications that have been associated with CVD risk, but unfortunately only provides a small improvement in risk prediction compared to the Framingham Risk Score among HIV+ individuals.[30] However, the TC/HDL-C had the strongest association with coronary atherosclerosis, which is consistent with data from other large non-HIV cohorts.[16] In addition, the TC/HDL-C is incorporated into the 2013 ACC/AHA Pooled Cohort Equation as it is the best lipid based predictor of CVD risk, because it incorporates both atherogenic (TC) and atheroprotective (HDL-C) lipid parameters. [15]

While traditional lipid parameters may be less predictive of atherosclerotic risk in HIV+ individuals, statins are a cornerstone of treatment and pitavastatin is being tested in the Randomized Trial to Prevent Vascular Events in HIV (REPRIEVE) to formally examine whether statins reduce atherosclerotic risk in HIV+ individuals who do not have a statin indication.[31].

People living with HIV infection have important differences in lipid composition due to increases in hepatic VLDL production and a decrease in overall lipid clearance compared with the general population. Untreated HIV infection is associated with higher triglycerides and lower HDL-C.[32] In the MACS, men who seroconverted to HIV during study follow-up were found to have a higher TC, LDL-C, and HDL-C levels before seroconversion.[12] The SMART study also showed that HDL-C levels decreased during HAART interruption, which was also associated with an increased CVD risk.[33] In addition, people treated with HAART have been demonstrated to have lower HDL-C levels even with appropriate CD4+ T cell counts, suppressed viral load, and decreased inflammation compared to those who are treated with HAART and the general population.[12, 34] These differences in lipid metabolism and composition along with increased inflammation and endothelial dysfunction likely contribute to the lower strength in association we observed for traditional lipids and subclinical coronary atherosclerosis.

Limitations of this study include the cross-sectional design, inclusion of only men, and differences in baseline lipid variables between HIV+ and HIV− participants. In order to account for these differences we included atherosclerotic risk factors as covariates in our statistical models.

This analysis has a number of important strengths including the large sample size of detailed characterization of subclinical coronary atherosclerosis by both CAC and coronary CTA,

which is unique in its ability to provide information on plaque composition. The MACS cohort is ethnically diverse and has a HIV− comparison group drawn from the same at risk population. In addition, the cohort is very well-characterized including the participants' atherosclerotic risk factors, markers of HIV infection control, and HIV medication use.

Overall, these results demonstrate that traditional serum lipid parameters tend to have weaker associations with subclinical coronary atherosclerosis in HIV+ compared to HIV− men. However, the strongest association was observed for TC/HDL-C and stenosis >50%. This weaker association may be secondary to changes in lipid parameters due to HIV infection, HAART use, and/or an increased role of non-lipid risk factors such as inflammation in the atherosclerotic process.[35] This weaker association may contribute to the decreased discrimination of atherosclerotic risk observed in HIV+ individuals and further research is necessary to describe the relationship of traditional lipid parameters and CVD outcomes in this unique population.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Dr. Whelton is supported by the PJ Schafer Memorial foundation.

This study is funded by the National Heart, Lung, and Blood Institute (grant RO1 HL095129 to Dr. Post), with additional support from the National Center for Advancing Translational Sciences, a component of the National Institutes of Health and National Institutes of Health Roadmap for Medical Research (grant UL1 RR 025005). The MACS is funded by the National Institute of Allergy and Infectious Diseases, with additional supplemental funding from the National Cancer Institute (grants UO1-AI-35042, UL1-RR025005, UM1-AI-35043, UO1-AI-35039, UO1-AI-35040, CTSI UL1TR001881, and UO1-AI-35041).

References

1. Freiberg MS, Chang CC, Kuller LH, Skanderson M, Lowy E, Kraemer KL, et al. HIV infection and the risk of acute myocardial infarction. JAMA Intern Med 2013,173:614–622. [PubMed: 23459863]
2. Silverberg MJ, Leyden WA, Xu L, Horberg MA, Chao CR, Towner WJ, et al. Immunodeficiency and risk of myocardial infarction among HIV-positive individuals with access to care. J Acquir Immune Defic Syndr 2014,65:160–166. [PubMed: 24442222]
3. Triant VA, Lee H, Hadigan C, Grinspoon SK. Increased acute myocardial infarction rates and cardiovascular risk factors among patients with human immunodeficiency virus disease. J Clin Endocrinol Metab 2007,92:2506–2512. [PubMed: 17456578]
4. Lichtenstein KA, Armon C, Buchacz K, Chmiel JS, Buckner K, Tedaldi EM, et al. Low CD4+ T cell count is a risk factor for cardiovascular disease events in the HIV outpatient study. Clin Infect Dis 2010,51:435–447. [PubMed: 20597691]
5. Holmberg SD, Moorman AC, Williamson JM, Tong TC, Ward DJ, Wood KC, et al. Protease inhibitors and cardiovascular outcomes in patients with HIV-1. Lancet 2002,360:1747–1748. [PubMed: 12480430]
6. Boulware DR, Hullsiek KH, Puronen CE, Rupert A, Baker JV, French MA, et al. Higher levels of CRP, D-dimer, IL-6, and hyaluronic acid before initiation of antiretroviral therapy (ART) are associated with increased risk of AIDS or death. J Infect Dis 2011,203:1637–1646. [PubMed: 21592994]
7. Klein D, Hurley LB, Quesenberry CP Jr., Sidney S Do protease inhibitors increase the risk for coronary heart disease in patients with HIV-1 infection? J Acquir Immune Defic Syndr 2002,30:471–477. [PubMed: 12154337]

8. Friis-Moller N, Weber R, Reiss P, Thiebaut R, Kirk O, d'Arminio Monforte A, et al. Cardiovascular disease risk factors in HIV patients--association with antiretroviral therapy. Results from the DAD study. AIDS 2003,17:1179–1193. [PubMed: 12819520]
9. Wolf K, Tsakiris DA, Weber R, Erb P, Battegay M. Antiretroviral therapy reduces markers of endothelial and coagulation activation in patients infected with human immunodeficiency virus type 1. J Infect Dis 2002,185:456–462. [PubMed: 11865397]
10. Lo J, Abbara S, Shturman L, Soni A, Wei J, Rocha-Filho JA, et al. Increased prevalence of subclinical coronary atherosclerosis detected by coronary computed tomography angiography in HIV-infected men. AIDS 2010,24:243–253. [PubMed: 19996940]
11. Post WS, George RT, Budoff M. HIV infection and subclinical coronary atherosclerosis. Ann Intern Med 2014,161:923–924.
12. Riddler SA, Smit E, Cole SR, Li R, Chmiel JS, Dobs A, et al. Impact of HIV infection and HAART on serum lipids in men. JAMA 2003,289:2978–2982. [PubMed: 12799406]
13. Tate T, Willig AL, Willig JH, Raper JL, Moneyham L, Kempf MC, et al. HIV infection and obesity: where did all the wasting go? Antivir Ther 2012,17:1281–1289. [PubMed: 22951353]
14. Currier JS, Lundgren JD, Carr A, Klein D, Sabin CA, Sax PE, et al. Epidemiological evidence for cardiovascular disease in HIV-infected patients and relationship to highly active antiretroviral therapy. Circulation 2008,118:e29–35. [PubMed: 18566319]
15. Goff DC Jr., Lloyd-Jones DM, Bennett G, Coady S, D'Agostino RB, Gibbons R, et al. 2013 ACC/AHA guideline on the assessment of cardiovascular risk: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. Circulation 2014,129:S49–73. [PubMed: 24222018]
16. Castelli WP, Anderson K, Wilson PW, Levy D. Lipids and risk of coronary heart disease. The Framingham Study. Ann Epidemiol 1992,2:23–28. [PubMed: 1342260]
17. Thompson-Paul AM, Lichtenstein KA, Armon C, Palella FJ Jr., Skarbinski J, Chmiel JS, et al. Cardiovascular Disease Risk Prediction in the HIV Outpatient Study. Clin Infect Dis 2016,63:1508–1516. [PubMed: 27613562]
18. Monroe AK, Haberlen SA, Post WS, Palella FJ Jr., Kinsgley LA, Witt MD, et al. Cardiovascular disease risk scores' relationship to subclinical cardiovascular disease among HIV-infected and HIV-uninfected men. AIDS 2016,30:2075–2084. [PubMed: 27203714]
19. Kaslow RA, Ostrow DG, Detels R, Phair JP, Polk BF, Rinaldo CR Jr. The Multicenter AIDS Cohort Study: rationale, organization, and selected characteristics of the participants. Am J Epidemiol 1987,126:310–318. [PubMed: 3300281]
20. Hacioglu Y, Gupta M, Choi TY, George RT, Deible CR, Jacobson LP, et al. Use of cardiac CT angiography imaging in an epidemiology study - the Methodology of the Multicenter AIDS Cohort Study cardiovascular disease substudy. Anadolu Kardiyol Derg 2013,13:207–214. [PubMed: 23376648]
21. Kingsley LA, Cuervo-Rojas J, Munoz A, Palella FJ, Post W, Witt MD, et al. Subclinical coronary atherosclerosis, HIV infection and antiretroviral therapy: Multicenter AIDS Cohort Study. AIDS 2008,22:1589–1599. [PubMed: 18670218]
22. Warnick GR, Albers JJ. A comprehensive evaluation of the heparin-manganese precipitation procedure for estimating high density lipoprotein cholesterol. J Lipid Res 1978,19:65–76. [PubMed: 202660]
23. Allain CC, Poon LS, Chan CS, Richmond W, Fu PC. Enzymatic determination of total serum cholesterol. Clin Chem 1974,20:470–475. [PubMed: 4818200]
24. Friedewald WT, Levy RI, Fredrickson DS. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clin Chem 1972,18:499–502. [PubMed: 4337382]
25. Schafer JL. Analysis of incomplete multivariate data New York, New York: Chapman and Hall.; 1997.
26. Subramanian S, Tawakol A, Burdo TH, Abbara S, Wei J, Vijayakumar J, et al. Arterial inflammation in patients with HIV. JAMA 2012,308:379–386. [PubMed: 22820791]

27. Bonnet F, Aurillac-Lavignolle V, Breilh D, Thiebaut R, Peuchant E, Bernard N, et al. Pravastatin in HIV-infected patients treated with protease inhibitors: a placebo-controlled randomized study. HIV Clin Trials 2007,8:53–60. [PubMed: 17434849]

28. Prevention of cardiovascular events and death with pravastatin in patients with coronary heart disease and a broad range of initial cholesterol levels. N Engl J Med 1998,339:1349–1357. [PubMed: 9841303]

29. Moyle GJ, Lloyd M, Reynolds B, Baldwin C, Mandalia S, Gazzard BG. Dietary advice with or without pravastatin for the management of hypercholesterolaemia associated with protease inhibitor therapy. AIDS 2001,15:1503–1508. [PubMed: 11504982]

30. Friis-Moller N, Thiebaut R, Reiss P, Weber R, Monforte AD, De Wit S, et al. Predicting the risk of cardiovascular disease in HIV-infected patients: the data collection on adverse effects of anti-HIV drugs study. Eur J Cardiovasc Prev Rehabil 2010,17:491–501. [PubMed: 20543702]

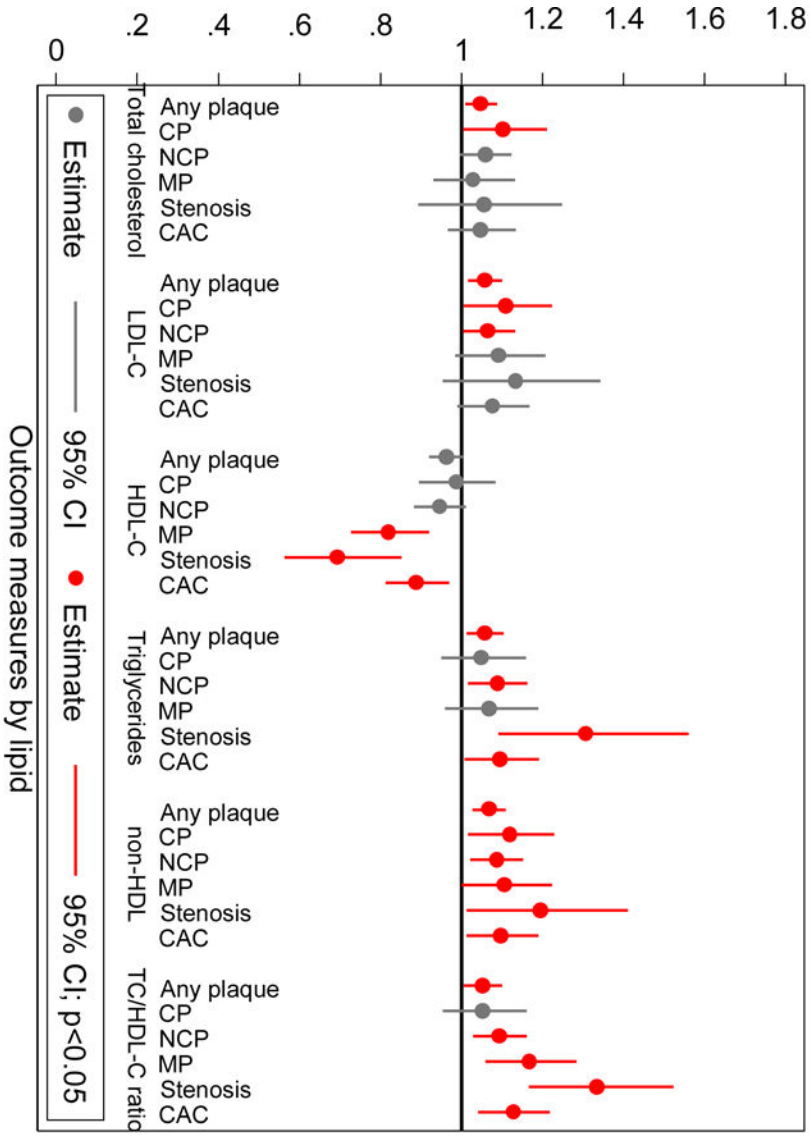
31. https://clinicaltrials.gov/ct2/show/NCT02344290. Accessed 05/21/2018.

32. Grunfeld C, Pang M, Doerrler W, Shigenaga JK, Jensen P, Feingold KR. Lipids, lipoproteins, triglyceride clearance, and cytokines in human immunodeficiency virus infection and the acquired immunodeficiency syndrome. J Clin Endocrinol Metab 1992,74:1045–1052. [PubMed: 1373735]

33. Duprez DA, Kuller LH, Tracy R, Otvos J, Cooper DA, Hoy J, et al. Lipoprotein particle subclasses, cardiovascular disease and HIV infection. Atherosclerosis 2009,207:524–529. [PubMed: 19515371]

34. Neuhaus J, Jacobs DR Jr., Baker JV, Calmy A, Duprez D, La Rosa A, et al. Markers of inflammation, coagulation, and renal function are elevated in adults with HIV infection. J Infect Dis 2010,201:1788–1795. [PubMed: 20446848]

35. Thomas GP, Li X, Post WS, Jacobson LP, Witt MD, Brown TT, et al. Associations between antiretroviral use and subclinical coronary atherosclerosis. AIDS 2016,30:2477–2486. [PubMed: 27490639]

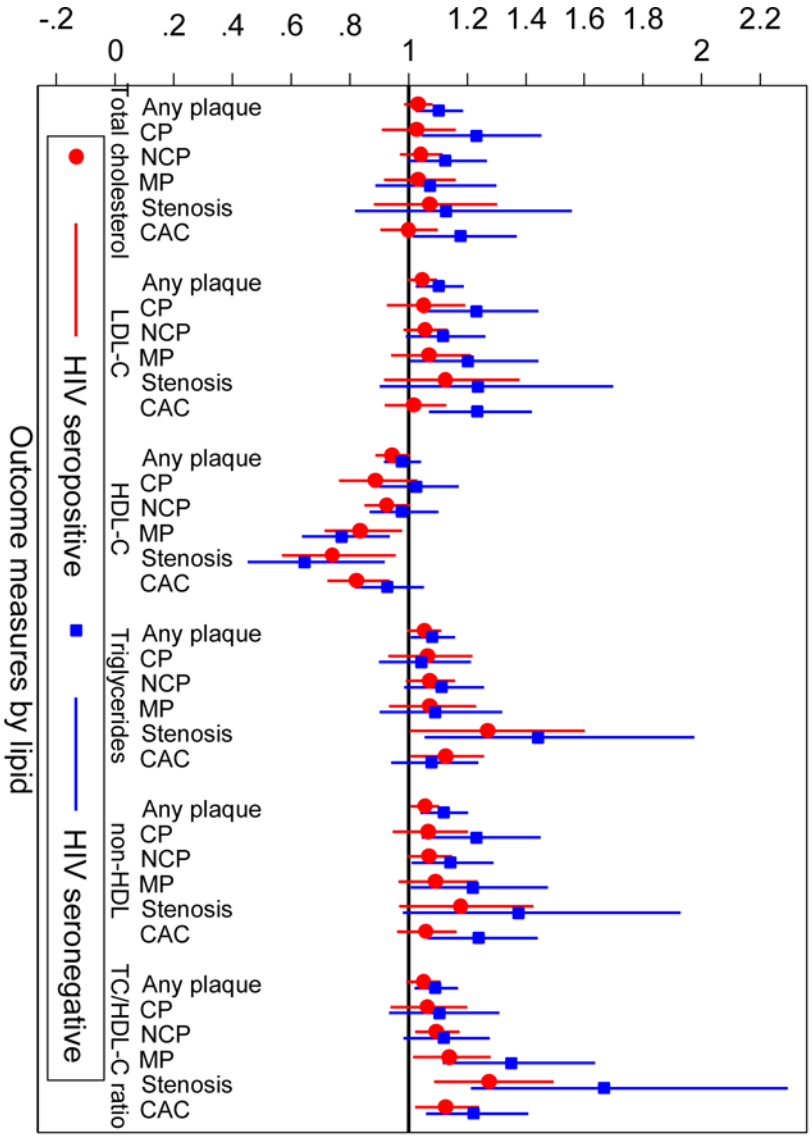


Adjusted for age, race (Caucasian, African-American, Hispanic and Other), study site, HIV serostatus, body mass index, systolic blood pressure, anti-hypertensive medication use, diabetes medication use, fasting glucose, and smoking status, and lipid-lowering medication use.

LDL-C - Low-density lipoprotein cholesterol, HDL-C - high density lipoprotein cholesterol, TC - total cholesterol, CP – Calcified plaque, NCP – Non-calcified plaque, MP – Mixed plaque, CAC – Coronary artery calcification

Figure 1.

Multivariable-adjusted Prevalence Ratios (PRs) Estimates and 95% Confidence Intervals (CIs) of the Presence of Plaque Outcomes Detected by Computed Tomography (CT) per Standard Deviation (SD) Increase in Lipid Parameters, Multicenter AIDS Cohort Study, N=732



Adjusted for age, race (Caucasian, African-American, Hispanic and Other), study site, body mass index, systolic blood pressure, anti-hypertensive medication use, diabetes medication use, fasting glucose, and smoking status, and lipid lowering medication use.

LDL-C - Low-density lipoprotein cholesterol, HDL-C - high density lipoprotein cholesterol, TC - total cholesterol, CP – Calcified plaque, NCP – Non-calcified plaque, MP – Mixed plaque, CAC – Coronary artery calcification

Figure 2.

Multivariable-adjusted Prevalence Ratios (PRs) Estimates and 95% Confidence Intervals (CIs) of the Presence of Plaque Outcomes Detected by Computed Tomography (CT) per Standard Deviation (SD) Increase in Lipid Parameters **by HIV Serostatus**, Multicenter AIDS Cohort Study, N=732

Table 1.

Study Population Characteristics by HIV Serostatus, Multicenter AIDS Cohort Study, N=732

	HIV infected (N=429)	HIV uninfected (N=303)	p-value
Demographics			
Age (years)	52.1 (6.5)	55.2 (7.3)	<0.0001
Race, %			
Caucasian	50.8	65.3	
African American	34.7	24.1	<0.0001
Hispanic and Other	14.5	7.6	
Body mass index (kg/m^2)	26.1 (4.2)	27.2 (4.9)	0.001
Smoking status, %			
Never	27.2	23.4	
Former	43.3	54.9	0.007
Current	29.5	21.7	
Systolic blood pressure (mmHg)	126.4 (14.2)	127.8 (14.6)	0.19
Anti-hypertensive medication, %	31.8	28.8	0.39
Diabetes, %	9.7	7.4	0.28
Lipid lowering medication, %	33.6	30.7	0.56
Lipid variables (mg/dL)			
Total cholesterol (TC)	185 (41)	193 (37)	0.005
Low density lipoprotein cholesterol (LDL-C)	108 (36)	116 (33)	0.003
High density lipoprotein cholesterol (HDL-C)	48 (15)	54 (15)	<0.0001
Triglycerides *	124 (91, 183)	105 (74, 146)	<0.0001
Non-HDL cholesterol (Non-HDL-C)	137 (38)	140 (35)	0.32
TC/HDL-C ratio	4.1 (1.3)	3.8 (1.1)	0.002
HIV variables			
History of AIDS, %	11.9	--	--
Detectable Viral Load, %	25.5	--	--
HIV RNA (copies/mL), *†	290 (52, 6,074)	--	--
Initiated HAART, %	97.4	--	--
Duration of HAART use (years)	8.9 (4.4)	--	--
Coronary plaque			
Any plaque on coronary CT angiography (CTA), %	78.3	74.6	0.24
Calcified plaque on CTA, %	34.5	40.3	0.11
Non-calcified plaque, %	63.2	53.1	0.007
Mixed plaque, %	34.5	31.7	0.43
Coronary Stenosis >50%, %	16.8	14.9	0.48
CAC score >10,%	42.0	43.6	0.67

Results presented as mean and standard deviation unless otherwise noted

*Median (25th and 75th Interquartile range)

†Among HIV infected participants with detectable viral load only

Table 2:

Adjusted Prevalence Ratios (PRs) Estimates and 95% Confidence Intervals (CIs) for Presence of Plaque Outcomes Detected by Computed Tomography (CT) per Standard Deviation (SD) Increase in Lipid Parameters by HIV status, Multicenter AIDS Cohort Study, N=732

	HIV-infected (N=429)		HIV-uninfected (N=303)	
	Model 1	Model 2	Model 1	Model 2
	PR (95% CI)	PR (95% CI)	PR (95% CI)	PR (95% CI)
Any Plaque				
Total Cholesterol	1.03 (0.99, 1.08)	1.03 (0.99, 1.08)	1.03 (0.99, 1.08)	1.07 (1.00, 1.15)
LDL-C	1.04 (0.99, 1.09)	**1.05 (1.00, 1.09)**	**1.05 (1.00, 1.10)**	**1.08 (1.01, 1.15)**
HDL-C	0.95 (0.89, 1.00)	0.95 (0.89, 1.00)	0.95 (0.89, 1.00)	0.98 (0.91, 1.03)
Triglycerides	**1.06 (1.01, 1.11)**	**1.05 (1.00, 1.10)**	**1.05 (0.99, 1.10)**	**1.07 (1.00, 1.14)**
Non-HDL-C	**1.06 (1.01, 1.10)**	**1.06 (1.01, 1.10)**	**1.06 (1.01, 1.10)**	**1.09 (1.02, 1.16)**
TC/HDL-C ratio	1.05 (0.99, 1.10)	1.05 (0.99, 1.10)	1.05 (0.99, 1.10)	**1.08 (1.01, 1.15)**
Calcified Plaque				
Total Cholesterol	1.02 (0.90, 1.14)	1.04 (0.91, 1.16)	1.04 (0.92, 1.16)	1.15 (0.99, 1.32)
LDL-C	1.02 (0.90, 1.15)	1.06 (0.93, 1.19)	1.06 (0.94, 1.19)	1.15 (0.98, 1.32)
HDL-C	0.91 (0.79, 1.03)	0.90 (0.78, 1.02) *	0.90 (0.78, 1.02)	1.07 (0.93, 1.20) *
Triglycerides	1.08 (0.95, 1.22)	1.05 (0.92, 1.18)	1.05 (0.92, 1.18)	0.99 (0.86, 1.12)
Non-HDL-C	1.05 (0.93, 1.17)	1.07 (0.95, 1.20)	1.08 (0.95, 1.20)	1.13 (0.96, 1.30)
TC/HDL-C ratio	1.03 (0.91, 1.14)	1.05 (0.93, 1.17)	1.05 (0.94, 1.17)	1.02 (0.85, 1.18)
Non-Calcified Plaque				
Total Cholesterol	1.03 (0.96, 1.10)	1.03 (0.96, 1.10)	1.03 (0.96, 1.10)	1.10 (0.97, 1.22)
LDL-C	1.04 (0.97, 1.11)	1.04 (0.97, 1.11)	1.04 (0.97, 1.11)	1.09 (0.97, 1.21)
HDL-C	**0.92 (0.84, 0.99)**	**0.92 (0.85, 1.00)**	**0.92 (0.85, 1.00)**	0.97 (0.86, 1.08)
Triglycerides	**1.10 (1.02, 1.18)**	**1.08 (1.00, 1.16)**	**1.08 (1.00, 1.15)**	1.10 (0.98, 1.22)
Non-HDL-C	**1.07 (1.00, 1.14)**	1.06 (0.99, 1.13)	1.06 (0.99, 1.13)	1.11 (0.99, 1.24)
TC/HDL-C ratio	**1.10 (1.02, 1.17)**	**1.09 (1.01, 1.16)**	**1.09 (1.02, 1.16)**	1.10 (0.97, 1.23)
Mixed Plaque				
Total Cholesterol	1.03 (0.91, 1.16)	1.05 (0.93, 1.17)	1.05 (0.93, 1.17)	1.05 (0.87, 1.22)
LDL-C	1.05 (0.92, 1.17)	1.09 (0.95, 1.22)	1.09 (0.96, 1.22)	1.12 (0.94, 1.31)
HDL-C	0.86 (0.74, 0.98)	0.84 (0.72, 0.96)	0.84 (0.71, 0.96)	0.81 (0.67, 0.96)
Triglycerides	1.10 (0.96, 1.24)	1.08 (0.94, 1.23)	1.09 (0.94, 1.23)	1.11 (0.93, 1.30)
Non-HDL-C	1.09 (0.96, 1.22)	1.12 (0.98, 1.25)	1.12 (0.98, 1.25)	1.15 (0.95, 1.34)
TC/HDL-C ratio	1.11 (0.99, 1.23)	**1.14 (1.02, 1.27)**	**1.15 (1.02, 1.27)**	**1.24 (1.03, 1.45)**
Stenosis >50%				
Total Cholesterol	1.03 (0.83, 1.23)	1.06 (0.86, 1.27)	1.07 (0.86, 1.27)	1.00 (0.71, 1.29)
LDL-C	1.03 (0.83, 1.24)	1.11 (0.89, 1.34)	1.12 (0.89, 1.34)	1.03 (0.74, 1.32)
HDL-C	**0.77 (0.58, 0.95)**	**0.74 (0.56, 0.93)**	**0.74 (0.56, 0.92)**	**0.63 (0.42, 0.83)**

	HIV-infected (N=429)		HIV-uninfected (N=303)	
	Model 1	**Model 2**	**Model 1**	**Model 2**
	PR (95% CI)	**PR (95% CI)**	**PR (95% CI)**	**PR (95% CI)**
Triglycerides	**1.29 (1.04, 1.54)**	1.25 (0.99, 1.50)	1.25 (0.99, 1.50)	**1.53 (1.14, 1.91)**
Non-HDL-C	1.12 (0.90, 1.34)	1.17 (0.94, 1.40)	1.17 (0.95, 1.40)	1.18 (0.85, 1.52)
TC/HDL-C ratio	**1.19 (1.01, 1.37)**	**1.25 (1. 07, 1.43)**	**1.26 (1.08, 1.44)**	**1.46 (1.08, 1.85)**
CAC				
Total Cholesterol	0.99 (0.90, 1.09)	1.01 (0.92, 1.11)	1.01 (0.92, 1.11)	1.11 (0.96, 1.26)
LDL-C	0.99 (0.89, 1.09)	1.04 (0.93, 1.14)	1.04 (0.94, 1.14)	**1.16 (1.00, 1.31)**
HDL-C	0.88 (0.78, 0.98)	0.86 (0.76, 0.96)	0.86 (0.75, 0.95)	0.93 (0.81, 1.05)
Triglycerides	**1.11 (1.00, 1.22)**	1.09 (0.98, 1.20)	1.09 (0.98, 1.20)	1.06 (0.94, 1.19)
Non-HDL-C	1.03 (0.93, 1.13)	1.06 (0.96, 1.17)	1.07 (0.97, 1.17)	**1.16 (1.00, 1.32)**
TC/HDL-C ratio	1.06 (0.96, 1.16)	**1.10 (1.00, 1.20)**	**1.10 (1.00, 1.21)**	**1.17 (1.02, 1.32)**

* P-value for Wald test for statistical interaction between HIV serostatus and lipid parameter <0.10

Model 1: age, race, study site

Model 2: age, race, study site, body mass index, systolic blood pressure, anti-hypertensive medication use, diabetes medication use, fasting glucose, lipid-lowering medication use, and smoking status

Prevalence ratios were derived independently for each lipid variable

Table 3:

Multivariable-adjusted Prevalence Ratios (PRs) Estimates and 95% Confidence Intervals (CIs) of the Presence of Plaque Outcomes Detected by Computed Tomography (CT) Scan per Standard Deviation (SD) Increase in Lipid Parameters by Lipid Lowering Medication Use Status, Multicenter AIDS Cohort Study, N=718

	Not on lipid lowering medication (N= 442)		**On lipid lowering medication (N=236)**	
	Model 1	**Model 2**	**Model 1**	**Model 2**
	PR (95% CI)	**PR (95% CI)**	**PR (95% CI)**	**PR (95% CI)**
Any Plaque				
Total Cholesterol	**1.06 (1.01, 1.12)**	**1.06 (1.00, 1.12)**	1.02 (0.98, 1.12)	1.03 (0.98, 1.07)
LDL-C	**1.07 (1.01, 1.13)**	**1.07 (1.01, 1.13)**	1.03 (0.98, 1.08)	1.04 (0.99, 1.09)
HDL-C	0.96 (0.91, 1.01)	0.97 (0.91, 1.02)	0.93 (0.87, 1.00)	0.94 (0.88, 1.00)
Triglycerides	**1.07 (1.01, 1.13)**	**1.06 (1.00, 1.11)**	**1.06 (1.01, 1.12)**	**1.05 (1.00, 1.11)**
Non-HDL-C	**1.08 (1.03, 1.14)**	**1.08 (1.02, 1.14)**	**1.05 (1.00, 1.10)**	**1.05 (1.00, 1.10)**
TC/HDL-C ratio	**1.07 (1.01, 1.13)**	**1.06 (1.00, 1.12)**	**1.06 (1.01, 1.12)**	**1.06 (1.00, 1.11)**
Calcified Plaque				
Total Cholesterol	1.13 (0.98, 1.27)	1.13 (0.98, 1.27)	1.03 (0.89, 1.16)	1.03 (0.90, 1.17)
LDL-C	1.13 (0.98, 1.29)	1.14 (0.99, 1.29)	1.03 (0.89, .118)	1.04 (0.89, 1.20)
HDL-C	0.95 (0.82, 1.07)	0.95 (0.83, 1.07)	1.01 (0.88, 1.14)	1.01 (0.88, 1.14)
Triglycerides	1.11 (0.97, 1.26)	1.09 (0.95, 1.23)	0.95 (0.84, 1.07)	0.95 (0.83, 1.07)
Non-HDL-C	**1.16 (1.01, 1.31)**	**1.15 (1.01, 1.30)**	1.02 (0.89, 1.16)	1.03 (0.89, 1.17)
TC/HDL-C ratio	1.09 (0.96, 1.22)	1.08 (0.95, 1.21)	0.98 (0.84, 1.12)	0.99 (0.84, 1.14)
Non-Calcified Plaque				
Total Cholesterol	1.05 (0.97, 1.14)	1.05 (0.97, 1.13)	1.05 90.97, 1.14)	1.05 (0.97, 1.14)
LDL-C	1.07 (0.99, 1.15)	1.06 (0.98, 1.15)	1.04 (0.96, 1.13)	1.05 (0.96, 1.14)
HDL-C	0.93 90.85, 1.00)	0.94 (0.86, 1.02)	0.93 (0.84, 1.03)	0.95 (0.85, 1.04)
Triglycerides	**1.09 (1.00, 1.18)**	1.07 (0.98, 1.16)	**1.13 (1.02, 1.23)**	**1.11 (1.01, 1.21)**
Non-HDL-C	**1.09 (1.00, 1.17)**	**1.08 (0.99, 1.16)**	**1.09 (1.00, 1.18)**	1.08 (0.99, 1.17)
TC/HDL-C ratio	**1.11 (1.03, 1.19)**	**1.09 (1.01, 1.18)**	**1.11 (1.02, 1.19)**	**1.09 (1.00, 1.17)**
Mixed Plaque				
Total Cholesterol	**1.16 (1.00, 1.31)** **	1.15 (0.99, 1.30) **	0.93 (0.80, 1.06) **	0.94 (0.81, 1.07) **
LDL-C	**1.21 (1.05, 1.38)** **	**1.21 (1.05, 1.38)** **	0.93 (0.79, 1.07) **	0.95 (0.80, 1.10) **
HDL-C	0.88 (0.76, 1.01)	**0.86 (0.73, 0.99)**	**0.79 (0.66, 0.93)**	**0.77 (0.64, 0.90)**
Triglycerides	1.06 (0.91, 1.20)	1.06 (0.92, 1.21)	1.13 (0.97, 1.30)	1.14 (0.97, 1.31)
Non-HDL-C	1.22 (1.05, 1.39) *	**1.22 (1.05, 1.39)** *	1.00 (0.85, 1.14) *	1.01 (0.87, 1.16) *
TC/HDL-C ratio	**1.17 (1.02, 1.32)**	**1.18 (1.03, 1.33)**	1.12 (0.98, 1.26)	**1.15 (1.00, 1.30)**
Stenosis >50%				
Total Cholesterol	1.07 (0.80, 1.34)	1.06 (0.79, 1.33)	1.01 (0.80, 1.23)	1.03 (0.81, 1.25)
LDL-C	1.13 (0.84, 1.41)	1.13 (0.84, 1.41)	1.02 (0.79, 1.24)	1.07 (0.82, 1.31)
HDL-C	**0.60 (0.42, 0.78)** *	**0.59 (0.41, 0.76)** *	0.83 (0.62, 1.04) *	0.82 (0.61, 1.03) *

	Not on lipid lowering medication (N= 442)		On lipid lowering medication (N=236)	
	Model 1	**Model 2**	**Model 1**	**Model 2**
	PR (95% CI)	**PR (95% CI)**	**PR (95% CI)**	**PR (95% CI)**
Triglycerides	**1.55 (1.22, 1.88)** *	**1.56 (1.22, 1.90)** *	1.17 (0.92, 1.43) *	1.17 (0.90, 1.43) *
Non-HDL-C	1.27 (0.96, 1.58)	1.26 (0.96, 1.57)	1.08 (0.84, 1.31)	1.10 (0.86, 1.34)
TC/HDL-C ratio	**1.36 (1.12, 161)**	**1.39 (1.13, 1.65)**	1.18 (0.95, 1.40)	1.20 (0.97, 1.42)
CAC				
Total Cholesterol	**1.15 (1.01, 1.28)** **	**1.14 (1.01, 1.27)** **	0.95 (0.85, 1.06) **	0.96 (0.86, 1.06) **
LDL-C	**1.19 (1.05, 1.33)** **	**1.19 (1.05, 1.33)** **	0.95 (0.84, 1.06) **	0.95 (0.84, 1.07) **
HDL-C	**0.87 (0.75, 0.98)**	**0.85 (0.75, 0.96)**	0.96 (0.84, 1.07)	0.94 (0.83, 1.05)
Triglycerides	**1.14 (1.01, 1.27)** *	**1.14 (1.01, 1.27)**	1.00 (0.90, 1.10) *	1.01 (0.91, 1.11)
Non-HDL-C	**1.22 (1.08, 1.36)** **	**1.22 (1.08, 1.36)** **	0.96 (0.85, 1.07) **	0.97 (0.86, 1.08) **
TC/HDL-C ratio	**1.19 (1.07, 1.32)** **	**1.20 (1.07, 1.33)** **	0.98 (0.86, 1.10) **	1.00 (0.88, 1.13) **

Abbreviations: CAC, coronary artery calcium; CI, confidence interval; HDL-C, High density lipoprotein; LDL-C, Low density lipoprotein; PR, Prevalence ratio; TC, total cholesterol

* P-value for Wald test for statistical interaction between lipid lowering medication use and lipid parameter <0.10

** P-value for Wald test for statistical interaction between lipid lowering medication use and lipid parameter <0.05

Model 1: age, race (Caucasian, African-American, Hispanic and Other), study site, HIV serostatus

Model 2: age, race (Caucasian, African-American, Hispanic and Other), study site, HIV serostatus, body mass index, systolic blood pressure, anti-hypertensive medication use, diabetes medication use, fasting glucose, lipid-lowering medication use, and smoking status