Non-HDL Cholesterol as a Predictor of Cardiovascular Disease in Type 2 Diabetes

The Strong Heart Study

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OBJECTIVE — To determine whether non-HDL cholesterol, a measure of total cholesterol minus HDL cholesterol, is a predictor of CVD in patients with diabetes.

RESEARCH DESIGN AND METHODS — The Strong Heart Study, a population-based study of CVD and its risk factors in 13 American Indian communities in three geographic areas in the U.S. The baseline examination, conducted between July 1989 and January 1992, consisted of a personal interview, a physical examination, and laboratory tests. Of the 4,549 women and men aged 45–74 years participating in the study, 2,108 had diabetes but no CVD at baseline. Data on fatal and nonfatal CVD were collected during the follow-up period through 31 December 1998 (average 9 years).

RESULTS — Multivariable analyses indicated that non-HDL cholesterol is a strong predictor of CVD in men and women with diabetes and is particularly indicative of coronary events. Hazard ratios for the highest tertile of non-HDL cholesterol in men and women with diabetes (2.23 and 1.80, respectively) were higher than those for either LDL cholesterol or triglycerides alone in both men and women and were higher than the ratio of total/HDL cholesterol in women. The utility of non-HDL cholesterol in predicting CVD extended over a wide range of triglyceride concentrations.

CONCLUSIONS — This study suggests that non-HDL cholesterol index may be particularly useful in predicting CVD risk in patients with diabetes.

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C ardiovascular disease (CVD) is currently the primary cause of morbidity and mortality in patients with diabetes (1–4). Because individuals with diabetes have greatly increased CVD risk compared with nondiabetic individuals (5–9), it is important to identify factors that may increase CVD risk in diabetic patients.

In type 2 diabetes, there is a characteristic dyslipidemia consisting of elevated triglycerides, decreased HDL cholesterol, and LDL particles of altered composition (10–12). Previous studies (5–9,13–15) indicate that, in addition to LDL cholesterol level, this dyslipidemia is an important CVD risk factor in individuals with diabetes. Although the CVD risk associated with individual lipoproteins has been examined, it would be valuable to have a measure that reflects the combined risk of all lipoprotein changes observed in diabetes. Some investigators (16–18) have recently suggested that a measure of non-HDL cholesterol, which reflects total cholesterol minus HDL cholesterol (i.e., all apolipoprotein B–containing atherogenic lipoproteins), might be a useful marker of this combined risk. A recent study conducted in a cohort containing both diabetic and nondiabetic individuals showed that non-HDL cholesterol was a somewhat better predictor of CVD than LDL cholesterol (19). Furthermore, the Adult Treatment Panel (ATP-III) of the National Cholesterol Education Program has recommended using non-HDL cholesterol in assessing CVD risk in patients with diabetes (20). However, there have been no population-based studies evaluating the utility of non-HDL cholesterol as a predictor of CVD in patients with diabetes.

The Strong Heart Study is a population-based study of CVD and its risk factors in American Indians. This population has a high prevalence of diabetes, and those with diabetes have a greatly increased risk of CVD (5). Using the data from this population, the purpose of this study is to evaluate the ability of non-HDL cholesterol and individual lipoprotein indicators to predict CVD in patients with diabetes.

RESEARCH DESIGN AND METHODS — The study design, survey methods, and laboratory techniques of the Strong Heart Study have been reported previously in detail (21,22). The baseline examination included American

Table 1—*Selected CVD risk factors at 9-year follow-up in diabetic men and women with and without CVD at baseline: the Strong Heart Study*

Characteristics	Men			Women		
	CVD	Non-CVD	P	CVD	Non-CVD	P
Participants (n)	202	570		319	1017	
Age (years)	58 ± 8	56 ± 8	<0.0001	60 ± 8†	57 ± 8†	<0.0001
BMI (kg/m^2)	31 ± 7	32 ± 6	0.0433	32 ± 6	33 ± 6†	0.0058
Waist circumference (cm)	105 ± 14	107 ± 14	0.0492	110 ± 14†	111 ± 14†	0.1022
HbA$_{1c}$ (%)	8.5 ± 2.5	7.9 ± 2.3	0.0015	9.0 ± 2.5	8.5 ± 2.5†	0.0094
SBP (mmHg)	133 ± 20	130 ± 18	0.0008	138 ± 24	128 ± 19	<0.0001
DBP (mmHg)	81 ± 10	81 ± 10	0.9044	76 ± 10†	75 ± 9†	0.3253
Hypertension (%)	38	31	0.1021	42	27	<0.0001
Current smoker (%)	37	33	0.3421	26†	22†	0.1448
Fasting plasma glucose (mg/dl)	200 ± 78	188 ± 72	0.0443	216 ± 85	204 ± 83†	0.0344
2-h plasma glucose (mg/dl)	300 ± 118	274 ± 113	0.0898	310 ± 104	299 ± 113†	0.3668
Insulin (μU/ml)*	19 (16–21)	19 (18–20)	0.8535	23 (21–24)	23 (22–24)†	0.115
Total cholesterol (mg/dl)	196 ± 47	184 ± 46	0.0019	205 ± 48	187 ± 39	<0.0001
HDL cholesterol (mg/dl)	39 ± 12	41 ± 12	0.0502	44 ± 11†	45 ± 11†	0.6238
LDL cholesterol (mg/dl)	109 ± 35	102 ± 31	0.0127	112 ± 37	102 ± 31	<0.0001
Triglycerides (mg/dl)*	151 (141–173)	136 (129–142)	0.0171	162 (150–173)	142 (137–146)	<0.0001
Ratio of albumin/creatinine*	86 (48–131)	26 (21–31)	<0.0001	79 (52–112)	32 (28–37)	<0.0001
Fibrinogen (mg/dl)	323 ± 82	300 ± 81	0.0003	348 ± 86†	326 ± 84†	<0.0001
Non-HDL cholesterol	157 ± 48	143 ± 47	0.0004	160 ± 49	143 ± 40	<0.0001
Ratio of total/HDL cholesterol	5.3 ± 1.7	4.8 ± 2.5	0.0027	4.9 ± 1.8†	4.4 ± 1.4†	<0.0001

Data are means ± SD or %. *Geometric mean values and 95% CI; †significant difference (P < 0.05) between diabetic men and women with CVD or between men and women without CVD.

Indians aged 45–74 years who were resident members of the following tribes between July 1989 and January 1992: the Akimel O'odham (Pima), Pee Posh (Maricopa), and Tohono-Oodham (Papago) tribes of central Arizona who live in the Gila River, Salt River, and Ak-Chin communities; the seven tribes of southwestern Oklahoma (Apache, Caddo, Comanche, Delaware, Fort Sill Apache, Kiowa, and Wichita); and the Oglala and Cheyenne River Sioux in South Dakota and the Spirit Lake Community in the Fort Totten area of North Dakota (23).

The baseline examination consisted of personal interviews, physical examinations, laboratory tests, and 12-lead resting electrocardiograms of 4,549 men and women. Participants were examined in the morning after at least a 12-h overnight fast. After informed consent was obtained, fasting blood samples were collected for measurement of lipid and lipoprotein levels. A 75-g oral glucose tolerance test was administered, and plasma glucose was measured 2 h after the glucose load (21). All laboratory tests were performed centrally. Standard assays were used to measure plasma glucose (24), cholesterol (24), triglyceride (24), lipid, and lipoprotein levels (25); fibrino-

gen determinations (26); HbA$_{1c}$ (27), urinary albumin (28), and urinary creatinine levels (29); and LDL particle size (30).

Anthropometric measurements were made with the participant wearing lightweight clothing and no shoes (22). BMI was calculated as weight (in kilograms)/height (in meters) squared. Waist circumference was measured at the level of the umbilicus with the participant in the supine position (31). Participants were considered to have hypertension if systolic blood pressure (SBP) was ≥140 mmHg or diastolic blood pressure (DBP) was ≥90 mmHg or if they were taking antihypertensive medication.

Diabetes was determined by World Health Organization recommendations (32), i.e., treatment with insulin or oral hypoglycemic agents, fasting plasma glucose level ≥126 mg/dl, or 2-h plasma glucose level ≥200 mg/dl after a 75-g glucose tolerance test.

Of the 4,549 participants examined at baseline, for 4,168 patients, diabetes status had been determined, lipoprotein measurements were available, and no CVD was present. Of these individuals, 2,108 had diabetes but no CVD at baseline and were included in this analysis. Total deaths and fatal CVD occurring be-

tween baseline and 31 December 1998 were identified through death certificates and tribal and Indian Health Service hospital records and by direct contact of study personnel with the study participants and their families. The process used to confirm CVD deaths has been described previously (21). Primary CVD deaths included myocardial infarction (MI), sudden cardiac death, coronary heart disease (CHD), stroke, congestive heart failure, and other fatal CVD. For nonfatal CVD, medical histories or medical records were reviewed during the second and third examinations to ascertain nonfatal CVD events that had occurred during follow-up. The process used to confirm nonfatal CVD events has been described previously (21). The nonfatal CVD events used in this study were CHD, MI, stroke, and other CVD. All fatal and nonfatal events were reviewed by committee following standard criteria to classify CVD (33).

Data were analyzed using SAS statistical software (Version 8.1; SAS Institute, Cary, NC). Incidence rates for fatal and nonfatal CVD were calculated per 1,000 person-years. Person-years were calculated from the date of the baseline examination to the date of the fatal event, the

Table 2—*Adjusted HRs for overall CVD by tertiles of non-HDL cholesterol in diabetic American Indians: the Strong Heart Study*

	Men		Women	
Tertiles*	Case/person-year†	HR (95% CI)‡	Case/person-year§	HR (95% CI)‡
Non-HDL cholesterol (mg/dl)				
T-1	57/1,894	1	78/3,404	1
T-2	56/1,883	1.02 (0.69–1.52)	105/3,344	1.33 (0.96–1.83)
T-3	89/1,654	2.23 (1.41–3.43)	136/3,123	1.80 (1.32–2.46)
HDL cholesterol (mg/dl)				
T-1	89/1,789	1	106/3,314	1
T-2	64/1,862	0.76 (0.54–1.07)	121/3,509	1.02 (0.77–1.36)
T-3	49/1,780	0.59 (0.40–0.88)	92/3,048	0.97 (0.71–1.32)
LDL cholesterol (mg/dl)				
T-1	57/1,905	1	88/3,364	1
T-2	70/1,794	1.34 (0.89–1.92)	103/3,327	1.23 (0.91–1.68)
T-3	75/1,732	1.71 (1.17–2.48)	128/3,180	1.61 (1.19–2.17)
Triglycerides (mg/dl)				
T-1	56/1,875	1	78/3,428	1
T-2	68/1,798	1.40 (0.94–2.07)	110/3,324	1.36 (0.99–1.87)
T-3	78/1,758	1.39 (1.00–1.98)	131/3,119	1.61 (1.17–2.22)
Ratio of total/HDL cholesterol				
T-1	43/1,937	1	86/3,401	1
T-2	68/1,838	1.85 (1.23–2.79)	102/3,313	1.16 (0.85–1.59)
T-3	91/1,655	2.46 (1.65–3.68)	131/3,157	1.48 (1.09–2.00)
Total	202/5,431		319/9,871	

Tertiles for diabetic men: non-HDL, <127, 127–162, >162; HDL, 36, 36–44, >44; LDL, <91, 91–115, >115; triglyceride, <106, 106–175, >175; total/HDL ratio, <4.1, 4.1–5.3, >5.3. Tertiles for diabetic women: non-HDL, <127, 127–160, >160; HDL, <40, 40–49, >49; LDL, <90, 90–115, >115; triglyceride, <113, 113–176, >176; total/HDL ratio, <3.8, 3.8–4.9, >4.9. †Case/person-year: diabetic (n = 772) and nondiabetic (n = 913). §Case/person-year: diabetic (n = 1,336) and nondiabetic (n = 1,147). ‡Adjusted for age, BMI, smoking status, study center, systolic blood pressure, HbA$_{1c}$, fibrinogen, insulin, and ratio of albumin to creatine.

first nonfatal event, or 31 December 1998 in event-free individuals. Subsequent analyses focused on comparisons between diabetic individuals who did and did not develop CVD. ANOVA was used for continuous variables and the χ^2 test was used for categorical variables.

Cox multivariate regression models were used to calculate the hazard ratios (HRs) and 95% CIs for tertiles of baseline non-HDL cholesterol, HDL cholesterol, LDL cholesterol, triglycerides, and ratio of total to HDL cholesterol to evaluate their independent roles as predictors of fatal and nonfatal CVD by sex, adjusted for confounding variables. Cox models were also used to calculate HRs and 95% CIs for non-HDL cholesterol and other levels to assess the association with incidence of CHD, MI, stroke, and all CVD in patients with diabetes. Kaplan-Meier plots for the proportion of patients with diabetes in whom CVD developed over 9 years of follow-up were estimated using the product-limit method. Statistical significance was defined either as $P < 0.05$ or 95% CIs for HRs that did not include 1.0. Because of their severely skewed dis-tributions, insulin, triglycerides, and ratio of albumin to creatinine were log-transformed for statistical analyses.

RESULTS — Univariate comparisons of baseline CVD risk factors in patients with diabetes in whom CVD did and did not develop during follow-up are shown in Table 1. Compared with those who did not develop CVD, men and women with diabetes in whom CVD developed were older and had higher HbA$_{1c}$ and SBP. Baseline total cholesterol, LDL cholesterol, triglycerides, VLDL triglycerides, VLDL cholesterol, albumin/creatinine ratio, fibrinogen, non-HDL cholesterol, and total/HDL cholesterol ratio were all significantly higher in patients with diabetes in whom CVD developed than in those with no CVD.

During the 9-year follow-up, CVD developed in 521 of the 2,108 diabetic participants and 145 of the 2,060 nondiabetic participants. The incidence of fatal and nonfatal CVD was 34.1/1,000 person-years (37.2 in men and 32.3 in women) in diabetic subjects and 8.9 in nondiabetic subjects (18.3 in men and 2.0

in women). The highest and middle tertiles of the lipoprotein parameters were compared with the lowest tertile in relation to CVD risk after adjustment for age, BMI, smoking status, study center, SBP, HbA$_{1c}$, fibrinogen, insulin, and albumin/creatinine ratio (Table 2). Although lipoprotein parameters were all significant predictors of CVD risk in men and women with diabetes (except HDL cholesterol in women), non-HDL cholesterol seemed to be the stronger predictor (except for total/HDL cholesterol ratio in men), with an HR of 2.23 (95% CI 1.41–3.43) in men and an HR of 1.80 (1.32–2.46) in women. A Kaplan-Meier plot by tertiles of non-HDL cholesterol (Fig. 1) shows continuous effects of non-HDL cholesterol on CVD risk in patients with diabetes over the 9-year follow-up period, especially for those in the highest tertile of non-HDL cholesterol.

Analyses of CVD subclasses were conducted in men and women combined. Increasing non-HDL cholesterol concentrations had significant, curvilinear relationships with CVD and CHD risk ($P < 0.001$) (Fig. 2). Compared with the refer-
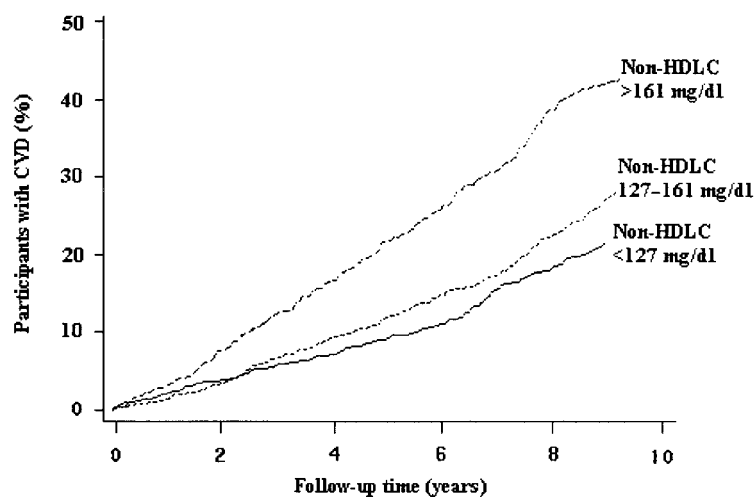
Figure 1—*Kaplan-Meier plot for CVD incidence by tertiles of non-HDL cholesterol: the Strong Heart Study.*

ence tertile, after adjustment for covariates (Table 3), non-HDL cholesterol was associated with a higher HR for MI than any of the lipid parameters and was higher than all but total/HDL ratio for CHD. However, there was overlap in the CIs.

Finally, we also compared the predictive value of non-HDL cholesterol for CHD and CVD in participants with triglyceride levels >150 and <150 mg/dl. The predictive value of non-HDL cholesterol was not greater in those with fasting triglyceride levels >150 mg/dl (Table 4). Similar results were observed for those with triglyceride levels ≥200 mg/dl, but the number of events was not adequate for stable estimates (data not shown).

CONCLUSIONS — The Adult Treatment Panel III of the National Cholesterol Education Program recently recommended that non-HDL cholesterol be used as a secondary target of therapy in people with triglyceride levels >200 mg/dl, especially those with diabetes or the metabolic syndrome (20). There are several advantages to the non-HDL cholesterol measurement. First, it makes no assumption about the relationship between VLDL cholesterol and triglycerides; in patients with diabetes, this relationship can be altered, leading to falsely low LDL values as calculated by the Friedewald formula, especially in conjunction with elevated triglyceride levels. Second, non-HDL cholesterol includes an assessment of all apolipoprotein B–containing lipoproteins considered to be atherogenic,

i.e., VLDL, intermediate-density lipoprotein (IDL), and LDL, and even lipoprotein(a). Finally, non-HDL cholesterol has several practical advantages in a clinical setting, including the ability to be assessed in patients with triglyceride levels >400 mg/dl and in patients who are not fasting (34–41).

Diabetes is associated with greatly increased CVD. Although many factors play a role in the accelerated atherosclerosis observed in diabetes, lipoprotein abnormalities are key contributors. LDL, the main cholesterol-bearing lipoprotein, is a major determinant of atherosclerosis in patients with diabetes. Whereas average LDL concentrations in patients with dia-

betes may not be higher than those of their nondiabetic counterparts, changes in LDL particle composition, such as density, oxidation potential, and glycation, render even normal LDL levels highly atherogenic (10,42). Other lipoprotein abnormalities in patients with diabetes include changes in triglyceride-rich lipoproteins (43,44). VLDL remnants and IDL accumulate as a result of altered lipoprotein metabolism; both types of particles have been shown to be highly atherogenic. Also, remnant triglyceride–rich lipoproteins can be taken up by macrophages, leading to increased foam cell formation and accelerated atherosclerosis in patients with elevated triglyceride levels (16). Elevated VLDL is also associated with increases in prothrombotic and procoagulant factors. Because of the many lipoprotein abnormalities in diabetes, an easily measured composite indicator may be useful to clinicians who treat patients with diabetes.

The Strong Heart Study cohort is an ideal population to assess the utility of non-HDL cholesterol in predicting CVD in patients with diabetes. This population includes a large number of individuals with type 2 diabetes who have been under continued surveillance since 1989. Our data show that in both men and women with diabetes, non-HDL cholesterol is a strong predictor of CVD; although the CIs were overlapping, HRs are higher than those for either LDL cholesterol or triglycerides alone. When compared with the ratio of total/HDL cholesterol, a compos-
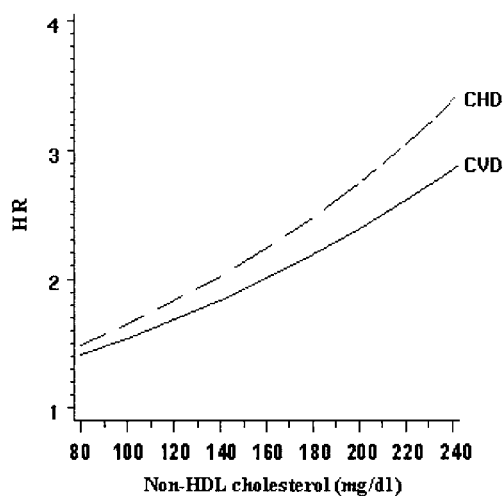
Figure 2—*Effect of non-HDL cholesterol on CVD and CHD, adjusted for sex, age, BMI, smoking status, study center, systolic blood pressure, HbA$_{1c}$, fibrinogen, insulin, and albumin to creatinine ratio: the Strong Heart Study.*

Table 3—Adjusted HRs for CVD by tertiles of non-HDL cholesterol in American Indians with diabetes: the Strong Heart Study

Strata	No.	CHD Case/person-year	CHD HR (95% CI)	MI Case/person-year	MI HR (95% CI)	Stroke Case/person-year	Stroke HR (95% CI)	CVD Case/person-year	CVD HR (95% CI)
Non-HDL cholesterol									
<127 mg/dl	706	42/5,703	1	17/5,806	1	24/5,780	1	135/5,297	1
127–161 mg/dl	714	65/5,674	1.37 (0.92–2.05)	26/5,801	1.60 (0.83–3.11)	29/5,769	0.85 (0.47–1.54)	160/5,276	1.21 (0.95–1.56)
>161 mg/dl	688	125/5,191	2.75 (1.91–3.97)	48/5,485	3.17 (1.72–5.84)	35/5,536	0.99 (0.56–1.74)	226/4,728	1.94 (1.53–2.46)
HDL cholesterol									
<39 mg/dl	777	111/5,895	1	44/6,124	1	32/5,802	1	210/5,415	1
39–47 mg/dl	684	70/5,428	0.75 (0.55–1.03)	26/5,608	0.67 (0.40–1.12)	35/5,603	1.24 (0.73–2.10)	166/5,024	0.84 (0.68–1.05)
>47 mg/dl	647	51/5,245	0.57 (0.39–0.82)	21/5,360	0.59 (0.34–1.04)	21/5,681	0.92 (0.49–1.69)	145/4,862	0.80 (0.63–1.02)
LDL cholesterol									
<91 mg/dl	728	57/5,834	1	23/5,961	1	30/5,922	1	146/5,433	1
91–115 mg/dl	683	72/5,382	1.29 (0.90–1.85)	27/5,556	1.28 (0.71–2.30)	21/5,588	0.66 (0.36–1.19)	172/4,956	1.28 (1.02–1.62)
>115 mg/dl	697	103/5,352	1.90 (1.35–2.67)	41/5,575	1.96 (1.14–3.37)	37/5,576	1.03 (0.61–1.75)	203/4,912	1.61 (1.29–2.02)
Triglycerides									
<111 mg/dl	714	45/5,733	1	18/5,829	1	24/6,178	1	131/5,347	1
111–175 mg/dl	691	76/5,425	1.98 (1.34–2.94)	29/5,617	1.56 (0.83–2.93)	30/5,550	1.28 (0.71–2.33)	179/5,017	1.44 (1.13–1.83)
>175 mg/dl	703	111/5,410	2.12 (1.44–3.11)	44/5,646	2.04 (1.12–3.69)	34/5,358	0.80 (0.43–1.50)	211/4,937	1.42 (1.11–1.81)
Total/HDL cholesterol ratio									
<3.9	702	39/5,753	1	19/5,814	1	21/5,802	1	128/5,362	1
3.9–5.0	704	83/5,517	2.11 (1.37–3.08)	27/5,722	1.69 (0.90–3.19)	34/5,681	1.27 (0.70–2.30)	181/5,090	1.50 (1.18–1.92)
>5.0	702	110/5,298	3.06 (2.03–4.59)	45/5,556	2.20 (1.21–3.98)	33/5,602	1.20 (0.64–2.23)	212/4,849	1.81 (1.41–2.31)
Total	2,108	232/16,568		91/17,092		88/17,085		521/15,301	

*Adjusted for sex, age, BMI, smoking status, study center, SBP, HbA$_{1c}$, fibrinogen, insulin, and albumin to creatinine ratio.

ite indicator suggested by the Framingham study (45), non-HDL cholesterol had a higher HR in women (1.80 vs. 1.48) but was slightly lower in men (2.23 vs. 2.46).

This report is the first population-based comparison of the utility of non-HDL cholesterol and individual lipoprotein parameters in predicting CVD in patients with diabetes. In the Systolic Hypertension in the Elderly Program (SHEP), a study of elderly, primarily white, nondiabetic individuals, non-HDL cholesterol was assessed along with serum cholesterol, triglycerides, LDL cholesterol, and HDL cholesterol as a predictor of cardiovascular events in 4,736 participants. During an average 4.5 years of follow-up, non-HDL cholesterol was shown to be a predictor of cardiovascular events in multivariate analysis in the total population. Non-HDL cholesterol and LDL cholesterol had similar HRs in individuals with triglyceride levels >400 mg/dl; however, non-HDL cholesterol, but not LDL cholesterol, was an independent predictor of CVD when triglycerides were included in the model (46). In the Gubbio study (47), a sample of 2,963 men and women aged 35–74 with no major CVD was examined in 1983. Risk factors were measured and 6-year incidence was computed for CHD and all cardiovascular events. Multivariate models showed that the relative risk for a difference of 40 mg/dl in non-HDL cholesterol ranged from 1.15 to 1.27. Findings from the Lipid Research Clinics Program Follow-Up Study, in which a total of 4,462 men and women were followed for 19 years, showed that non-HDL cholesterol emerged as a somewhat better predictor of CVD mortality than LDL (19). Our findings of the utility of non-HDL cholesterol as a predictor of CVD in a large cohort of patients with diabetes are of particular interest considering the dyslipidemia that is common in diabetes.

Our analyses provide strong supportive evidence that non-HDL cholesterol may be particularly useful in treating patients with diabetes. However, this analysis is restricted to American Indians, who have the highest rate of diabetes of any ethnic group in the U.S. (5). Ethnic differences in CVD risk factors and cultural/lifestyle practices require that our findings be confirmed in other diabetic populations. Importantly, because there were few cases of CVD in the nondiabetic

members of this cohort, it was not possible to adequately assess the utility of non-HDL cholesterol in individuals with the metabolic syndrome but without frank diabetes. This important question remains to be answered.

An important issue for interpretation of these results is the impact of the variance of a lipoprotein measure on its utility as a predictor of CVD. The intra-individual variation in triglyceride concentrations is much higher than that of HDL or LDL cholesterol. Therefore, it is not clear whether the diminished significance of triglycerides as a predictor is simply due to the fact that an accurate integrated measure of average triglyceride concentrations over a longer period of time cannot be obtained from a single fasting sample. Non-HDL cholesterol would be subjected to some of the same considerations. Although more stable than total triglyceride because a large component is LDL cholesterol, non-HDL cholesterol is also a reflection of VLDL and IDL cholesterol, which fluctuate widely in individuals from day to day, depending on dietary patterns and other metabolic variables. Use of non-HDL cholesterol in the nonfasting state, although feasible, would enhance this variability. Therefore, it is possible that this measure could be of even greater use if an integrated value that reflected days or weeks of combined VLDL, IDL, and LDL cholesterol concentrations could be developed.

In summary, our results show that non-HDL cholesterol is a significant predictor of CVD in diabetic men and women. Because diabetic patients are at high risk for CVD morbidity and mortality, adequate risk assessment and management is imperative. The simple non-HDL cholesterol measurement, which can be conducted in the nonfasting state and can be determined regardless of triglyceride concentration, may be of particular clinical utility. The Adult Treatment Panel (ATP-III) of the National Cholesterol Education Program recommended a therapeutic goal for non-HDL cholesterol of 30 mg/dl higher than the goal for LDL cholesterol; therefore, in patients with diabetes, the goal would be a non-HDL cholesterol target of <130 mg/dl.

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Table 4—Adjusted HRs (upper versus lower tertile) for CVD and CHD in diabetic individuals with triglyceride levels greater than, less than, or equal to 150 mg/dl: the Strong Heart Study

Lipoproteins	CHD		CVD		Triglycerides	
	>150	≤150	>150	≤150	>150	≤150
Non-HDL cholesterol (mg/dl)	1.78 (1.13–2.80)	2.79 (1.53–5.10)	1.52 (1.12–2.07)	1.80 (1.27–2.54)	>181 vs. <151	>147 vs. <115
HDL cholesterol (mg/dl)	0.75 (0.48–1.19)	0.49 (0.27–0.89)	0.99 (0.72–1.36)	0.67 (0.46–0.96)	>43 vs. <35	>50 vs. <41
LDL cholesterol (mg/dl)	1.86 (1.21–2.88)	2.28 (1.31–3.98)	1.58 (1.16–2.16)	1.66 (1.17–2.34)	>119 vs. <93	>113 vs. <89
Triglycerides (mg/dl)	1.05 (0.68–1.63)	1.51 (0.89–2.56)	1.02 (0.75–1.39)	1.29 (0.93–1.79)	>260 vs. <191	>117 vs. <88
Ratio of total/HDL cholesterol	1.74 (1.11–2.75)	3.69 (1.97–6.93)	1.26 (0.92–1.72)	1.99 (1.40–2.81)	>6.0 vs. <4.8	>4.4 vs. <3.5

*Adjusted for sex, age, BMI smoking status, study center, SBP, HbA$_{1c}$, fibrinogen, insulin, and albumin to creatinine ratio.

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