Clinica Chimica Acta 475 (2017) 22–27

Contents lists available at ScienceDirect

Clinica Chimica Acta

journal homepage: www.elsevier.com/locate/cca

Comparison of lipoprotein derived indices for evaluating cardio-metabolic risk factors and subclinical organ damage in middle-aged Chinese adults

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ARTICLE INFO

Keywords:
Triglycerides/high-density lipoprotein cholesterol ratio
Cardio-metabolic risk
Metabolic syndrome
Subclinical organ damage

ABSTRACT

Background: High-density lipoprotein cholesterol (HDL-C) and related lipoprotein ratios were used to assess lipid atherogenesis or insulin resistance. However, which of these indices is superior remains controversial and could differ across ethnic groups. We evaluated the efficacy of HDL-C, and related lipoprotein ratios in identifying cardio-metabolic risk factors (CMRs) or preclinical organ damage among a health check-ups population in China.
Methods: We conducted a cross-sectional study of 17,596 Chinese adults aged 40–64 years, who participated in annual health checkups in China. Anthropometric, biochemical, liver ultrasound scan, brachial-ankle pulse wave velocity (baPWV) and carotid intima-media thickness (cIMT) were analyzed. Partial spearman correlations, receiver operating characteristic (ROC) curves were used for statistical analyses.
Results: In both gender, the triglyceride to high-density lipoprotein cholesterol (TG/HDL-C) ratio consistently had the highest correlation with various CMRs and subclinical organ damage. Overall, the area under the curve (AUC) of TG/HDL-C ratio was significantly greater than that of the rest lipid variables/ratios in the prediction of abdominal obese, high blood pressure, impaired fasting glucose, metabolic syndrome, and preclinical signs of organ damage (all $P < 0.001$). In both gender with a normal TG and HDL-C concentration, those with an increased TG/HDL-C, had higher concentrations of various CMRs and higher presence of subclinical organ damage (despite no significant differences were found between different TG/HDL-C for part of CMRs indicators).
Conclusions: In this population, TG/HDL-C ratio of ≥ 1.255 in men and ≥ 0.865 in women can identify individuals with cardio-metabolic risk, despite TG/HDL-C ratio, TC/HDL-C ratio, and LDL-C/HDL-C ratio seem comparable in their association with CMRs and subclinical signs of organ damage.

1. Introduction

Transition on cardio-metabolic risk factors (CMRs) during middle age can increase lifetime risk for heart disease and stroke. Assessment of cardiovascular risk plays key roles in cardiovascular prevention [1]. Despite remarkable advances in recent years, the current approaches to evaluation of cardio-metabolic risk in asymptomatic individuals remain suboptimal in clinical practice. Regarding the traditional fasting plasma lipid profile (total cholesterol [TC], low-density lipoprotein cholesterol [LDL-C], high-density lipoprotein cholesterol [HDL-C], and triglycerides [TG]), several lipoprotein derived indices, such as LDL-C/HDL-C ratio, TC/HDL-C ratio, and TG/HDL-C ratio provide clues on risk factors with new perspective and could be better indicators of the interactions between lipid fractions [1]. However, research on comparing the 'ability' to distinguish individuals with cardio-metabolic risk factors between these lipid indices is limited, especially for Chinese.

There were tremendous evidences that an increased LDL-C concentration is linked to promoting atherosclerosis [2], however, a high HDL-C concentration is cardio-protective [3,4]. In view of this, the ratio of LDL-C/HDL-C is often calculated to estimate the coronary heart disease (CHD) risk [5]. However, the significance of detecting and properly analyzing the TC/HDL-C ratio (rather than the LDL-C/HDL-C ratio) is emphasized [6]. Despite the TC/HDL-C ratio was quite commonly used as a measure of lipid atherogenesis, its utility for assessing insulin resistance (IR) or its associated cardio-metabolic risk has not yet been clarified. Consequently, several researchers have identified an increased TG/HDL-C ratio as a predictor of cardiovascular events in the general population [7,8] and in some groups of patients at high risk [9]. Since the high TG/low HDL-C lipid phenotype associated with small, dense LDL particles has been revealed to be the most prevalent type for

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http://dx.doi.org/10.1016/j.cca.2017.09.014
Received 19 July 2017; Received in revised form 18 September 2017; Accepted 19 September 2017
Available online 29 September 2017
0009-8981/

Table 1
Characteristics of the study subjects[a].

Characteristics	Overall (N = 17,596)	Male (N = 10,073)	Female (N = 7523)	*P* value[b]
Age (y)	49.19 (6.64)	49.20(6.63)	49.16(6.65)	NS
Prevalence of lifestyle factors				
Current smoker, n (%)	4770 (27.11)	4332 (43.01)	132 (1.76)	< 0.001
Alcohol use, n (%)	1770 (10.06)	1610 (15.98)	47 (0.63)	< 0.001
Regular exercise, n (%)	7559 (42.96)	4286 (42.55)	3273 (43.51)	0.01
Sedentary time ≥ 4 h/d, n (%)	4179 (23.75)	2530 (25.12)	1649 (21.92)	< 0.001
Anthropometricindices				
Body mass index (kg/m^2)	24.35 (2.95)	25.22(2.82)	23.18(2.70)	< 0.001
Waist circumference (cm)	82.57 (8.91)	86.78(7.59)	76.92(7.27)	< 0.001
Cardiometabolic risk factors measures				
Systolic blood pressure(mmHg)	123.69 (14.84)	126.75(14.04)	119.59(14.89)	< 0.001
Diastolic blood pressure (mmHg)	78.13 (11.12)	81.48(10.65)	73.64(10.12)	< 0.001
Fasting plasma glucose[c] (mmol/l)	5.22 (4.91–5.56)	5.27(4.95–5.64)	5.14(4.86–5.46)	< 0.001
Fasting plasma triglycerides[c] (mmol/l)	1.32 (0.93–1.93)	1.57(1.10–2.30)	1.07(0.79–1.48)	< 0.001
Plasma HDL cholesterol (mmol/l)	1.63 (0.42)	1.46(0.35)	1.84(0.41)	< 0.001
Prevalence of cardiometabolic risk factors				
Abdominal obese, n (%)	6193 (35.20)	3609 (35.83)	2584 (34.35)	0.04
Impaired fasting glucose, n (%)	4113 (23.37)	2766 (27.46)	1347 (17.91)	< 0.001
High blood pressure, n (%)	7379 (41.94)	5137 (51.00)	2242 (29.80)	< 0.001
High plasma triglycerides, n (%)	5778 (32.84)	4452 (44.20)	1326 (17.63)	< 0.001
Low HDL cholesterol, n (%)	1165 (6.62)	632 (6.27)	533 (7.08)	0.03
Metabolic syndrome, n (%)	3460 (19.66)	2521 (25.03)	939 (12.48)	< 0.001
Prevalence of subclinical organ damage				
Liver steatosis, n (%)	4760 (27.05)	3485 (34.60)	1275 (16.95)	< 0.001
High cIMT[d], n (%)	1269 (48.94)	872 (50.09)	397 (46.60)	< 0.001
High baPWV[d], n (%)	2154 (53.03)	1464 (53.20)	690 (52.67)	< 0.001

Abbreviations: cIMT, carotid intima-media thickness; baPWV, brachial ankle pulse wave velocity.
[a] Values are expressed as mean (SD), number (%) unless otherwise stated.
[b] *P* values represent groups differences assessed from Mann-Whitney *U* test for fasting glucose and triglycerides, two independent samples *t*-test for all other continuous variables, and χ^2 test for categorical variables.
[c] Values are expressed as Median (Interquartile range) presented.
[d] cIMT, baPWV data were collected in 2593,4062 subjects, respectively.

ischemic cardiovascular disease [10], this ratio have been supported as a simple, robust risk indicator of lipid atherogenesis, similar to TC/HDL-C ratio, according to the recent meta-analyses [11,12]. Furthermore, from a recent study in Chinese youth and adolescents with newly diagnosed T2DM, it was found that TG/HDL-C ratio was an independent predictors of increased carotid intima-medial thickness (cIMT) in such patients [13]. This was consistent with the findings of a separate study in Italian overweight/obese children, showing that TG/HDL-C ratio was the better indicator than non-HDL-C for CMRs or preclinical signs of organ damage [14].

Nevertheless, several other studies yielded inconsistent results [15,16]. Meanwhile, whether TG/HDL-C ratio plays a better role in indicating CMRs or preclinical organ damage than the other common lipoprotein ratios in adults has not been studied extensively.

2. Methods

2.1. Participants and study design

We conducted a retrospective cross-sectional study, comprising community residents aged 40–60 years who underwent their annual health check-ups in the Health Management Center of the Third Xiangya Hospital, Central South University during 2013 to 2014. We retrospectively reviewed the consecutive health check-up records of 20,825 adults. Subjects with incomplete data, as well as those who were pregnant or had a chronic disease that may affect the metabolic status (e.g. presence of diabetes, hypertension, with a history of cardiovascular diseases, thyroid orhypothalamic disease, chronic hepatitis, cirrhosis, and/or under pharmacological treatment), were excluded from analyses (n = 3229). The sample used for the current analysis consisted of 10,073 men and 7523 women. The study was carried out in accordance with the Declaration of Helsinki and has been approved by the Institutional Review Board of the Third Xiangya Hospital, Central South University.

2.2. Measurements

The information of medical history, lifestyle behaviors and medication was based on the structured questionnaires. Trained staff reviewed the completed questionnaires and entered the responses into a database. The lifestyle behaviors mainly included cigarette smoking, alcohol consumption, and physical activity. If the participants currently undergoing treatments for any disease, they were asked for the information of diagnosis and medications. The anthropometric variables were measured with standard methods. Body mass index (BMI) was subsequently calculated.

Fasting venous blood samples were collected after 12 to 14 h of overnight fasting. Concentrations of fasting blood glucose (FBG), total cholesterol (TC), and triglycerides (TG) were determined by enzymatic colorimetric assay. High density lipoprotein cholesterol (HDL-C) concentration was measured by lipoprotein electrophoresis. Concentrations of serum TC, TG, and HDL-C were measured using Leadman reagents (Leadman). Low-density lipoprotein cholesterol (LDL-C) concentration was calculated according to the Friedewald formula.

2.3. Liver ultrasounds scan

The abdominal ultrasonographic scan for all participants was performed by six experienced ultrasonographer using the Acuson Sequoia 512 Ultrasound system. The size, echogenicity, contour, structure and posterior beam attenuation of the liver were assessed, respectively. Subjects with the following sonographic feature were diagnosed with fatty liver disease: increased liver echogenicity (bright), vessel blurring, stronger echoes in the hepatic parenchyma than in the renal parenchyma, and narrowing of the lumen of the hepatic veins. According to the criteria described by Saadeh et al. [17], the degree of liver