

Blood serum levels of lipids and apolipoproteins in women with angiographically defined coronary artery disease

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Objective. The goal of the study was to evaluate the role of blood serum lipids and A-I and B apolipoproteins (apo) in prediction of coronary artery disease (CAD) in women.

Material and methods. Ninety-two women undergoing diagnostic coronary angiography were examined. Weight and height were measured, body mass index (BMI) was calculated, and blood serum concentrations of total cholesterol (TC), high density lipoprotein cholesterol (HDLC), triglycerides (TG) were determined after an overnight fast during the day preceding the coronary angiography. In the same serum samples the levels of apoA-I and B were measured using monoclonal antibodies against apo (Spinreact AA, Sant Esteve De Bas, Spain) by the immunoturbidimetry method. The serum samples were kept frozen at -40°C until used. The women were divided into three groups depending on results of coronary angiography: the CAD-free group consisted of women with clear coronary arteries or insignificant irregularities in angiograms ($n = 31$, BMI 29.5 ± 4.5 ; mean age 63 ± 7.0 years), CAD group I – those with single stenoses more than 50 percent in one or two vessels ($n = 30$, BMI 31.0 ± 5.3 ; mean age 66 ± 7.6), and CAD group II – with multiple stenoses more than 50 percent in all three vessels including left main coronary artery ($n = 31$, BMI 30.4 ± 4.6 ; mean age 66 ± 7.1). The CAD groups I and II were pooled ($n = 61$) with the aim to compare the data with data of the CAD-free group.

Results. The age and BMI of participants in all groups were similar ($P > 0.05$). The differences in TC and HDLC between the CAD-free group and CAD group I, CAD group II and pooled CAD group were statistically insignificant (6.7 ± 1.18 vs. 6.12 ± 1.58 , 6.53 ± 1.23 and 6.33 ± 1.42 mmol/l; $P > 0.05$ and 1.36 ± 0.28 vs. 1.25 ± 0.20 , 1.28 ± 0.36 and 1.27 ± 0.29 mmol/l; $P > 0.05$, respectively). The blood serum concentrations of apoA-I were significantly higher in the CAD-free group compared to the CAD group I, CAD group II and pooled CAD group (1.26 ± 0.26 vs. 1.13 ± 0.14 , 1.14 ± 0.16 and 1.13 ± 0.15 g/l; $P < 0.05$, respectively). The TG levels were significantly lower in the CAD-free group compared to the CAD group I, CAD group II and pooled CAD group (1.34 ± 0.73 vs. 2.2 ± 0.99 , 1.82 ± 0.83 and 2.0 ± 0.92 mmol/l; $P < 0.02$, respectively). No differences in apoB level among all CAD groups as well as between the CAD-free group and CAD groups were determined ($P > 0.05$). The apoB/A-I ratio was found to be similar in all groups ($P > 0.05$).

Conclusions. The diagnostic significance of apoA-I is higher than of HDLC and TC in CAD prediction in women. Significant differences in TG level between the CAD groups and the CAD-free group could indicate the critical role of metabolic disorders in the development of CAD in women.

Key words: female gender, coronary heart disease, apolipoprotein A-I, triglycerides

INTRODUCTION

Cardiovascular disease is the most common cause of premature death and morbidity, and nearly half

of cardiovascular deaths result directly from coronary artery disease (CAD) (1, 2). An epidemiological data show that with age CAD becomes the leading cause of death among women as well as among men (3). Several major and independent risk factors for the clinical manifestations of atherosclerosis have been identified, including elevated serum total cholesterol (TC) and low density lipoprotein

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cholesterol (LDLC), low serum high density lipoprotein cholesterol (HDLC), cigarette smoking, elevated blood pressure, diabetes mellitus and advanced age (4), however, they may have a different relative importance in women compared to men (5). Additional factors such as hormonal status are powerful predictors of CAD in women (6). Dyslipidemia may also expose women to a greater risk than men, as elevated levels of triglycerides and low levels of HDLC are more strongly correlated with CAD in women (5). It has become clear that not all coronary events occur in individuals with traditional risk factors, and nearly half of myocardial infarctions occur among individuals without evident hyperlipidemia (7). Results of several studies have suggested that besides classic lipid factors, such as LDLC and HDLC, evaluation of apolipoprotein (apo) B and apoA-I could improve the prediction of risk of CAD (8, 9). Studies in men have demonstrated that apoB can be a valuable predictor for CAD (8, 10). In several studies gender differences of apo levels were examined in patients with angiographically defined CAD (10, 11).

The goal of the current study was to evaluate the relative role of the blood serum apolipoproteins A-I and B in prediction of CAD in women by comparing the levels of these apolipoproteins as well as TC, HDLC and triglycerides (TG) levels in women with different degree of coronary artery injury confirmed by coronary angiography and in control subjects (with angiographically negative – CAD-free patients).

MATERIALS AND METHODS

The study was performed in Klaipeda Seamen's Hospital (West Lithuania). The study protocol was approved by the Lithuanian Bioethics Committee (approval

No. 01-64/2001-11-28), and all subjects gave their written informed consent before recruited in the study.

The study population consisted of 92 women who were undergoing coronary angiography. The indications for angiography were suspicion of CAD or evaluation of previously diagnosed stable exertional angina. The participants underwent a clinical evaluation, which included a questionnaire that noted age, menopausal age, hypertension and diabetes history, smoking status. Women suffering from rheumatic valvular disease, significant heart, renal or hepatic failure, active infection or other illness which can influence lipid values, as well as women with unstable coronary syndrome or coronary angioplasty in the last three months were excluded from the study. Smoking women, as well as women using lipid lowering medication and/or preparations containing sexual hormones were also excluded. The anthropometric data (weight and height) were obtained. The body mass index (BMI) was calculated. Plasma concentrations of total cholesterol (TC), HDLC, TG, apoA-I and apoB were determined after an overnight fast during the day preceding the coronary angiography. TC, HDLC and TG were measured by the enzymatic colorimetric method on a COBAS-MIRA analyser using the Human diagnostic tests (Human GmbH, Wiesbaden, Germany). ApoA-I and apoB were measured by immunoturbidimetry on a COBAS-MIRA analyser using Spinreact (Spinreact S. A., Sant Esteve De Bas, Spain) reagents, calibrators and controls. The blood serum samples were kept frozen at -40°C until analysis. Samples were thawed only once before investigation. The ApoB/apoA-I ratio was calculated.

Coronary angiographies were performed according to the standard Judkins technique (12). Coronary artery stenosis more than 50 percent on visual examination was considered as CAD. Study partici-

Table. Age, BMI and lipid, apoA-I and B levels in women with and without CHD as assessed by coronary angiography

Indices	CAD-free group (n = 31)	CAD group I (n = 30)	CAD group II (n = 31)	CAD pooled group (n = 61)
Age, y	63 ± 7.0	66 ± 7.6	66 ± 7.1	66 ± 7.3
BMI, kg/m ²	29.5 ± 4.5	31.0 ± 5.3	30.4 ± 4.6	30.7 ± 5.0
Arterial hypertension (%)	77.4	90	93.5	91.8
TC, mmol/l	6.70 ± 1.18	6.12 ± 1.58	6.53 ± 1.23	6.33 ± 1.42
HDLC, mmol/l	1.36 ± 0.28	1.25 ± 0.20	1.28 ± 0.36	1.27 ± 0.29
TG, mmol/l	1.34 ± 0.73	2.20 ± 0.99**	1.82 ± 0.83*	2.00 ± 0.92**
ApoA-I, g/l	1.26 ± 0.26	1.13 ± 0.14*	1.14 ± 0.16*	1.13 ± 0.15*
ApoB, g/l	0.86 ± 0.19	0.87 ± 0.26	0.85 ± 0.19	0.86 ± 0.22
ApoB/A-I ratio	0.71 ± 0.21	0.78 ± 0.24	0.75 ± 0.19	0.77 ± 0.22

*P < 0.05 compared CAD-free group with another group.

**P < 0.001 compared CAD-free group with another group.

pants were divided into three groups, depending on the results of coronary angiography: the CAD-free group consisted of women with clear coronary arteries or insignificant irregularities on angiograms ($n = 31$); the CAD group I included women with single stenosis in one or two vessels ($n = 30$) and CAD group II with multiple stenoses in all three vessels including the left main coronary artery ($n = 31$). The CAD groups I and II were pooled ($n = 61$) with the aim to compare the data with data on the CAD-free group. The characteristics of the groups are shown in Table.

Student's *t* tests were used to analyze differences in plasma lipid and apolipoprotein concentrations between the groups. Plasma lipid and apolipoprotein concentration differences between the groups were analysed. Pearson's correlation coefficient *r* was used to measure the degree of association between different variables in each group. The values are expressed as mean \pm standart deviation ($M \pm SD$). Two-tailed *P* values <0.05 were considered significant.

RESULTS

The results are shown in Table. The age and BMI of participants in all groups were similar. The differences in TC and HDLC between the CAD-free group and CAD group I, group II and the pooled CAD group were statistically insignificant ($P > 0.05$). The blood serum concentrations of apoA-I were significantly higher in the CAD-free group compared in the other groups – the pooled CAD group ($P < 0.02$), CHD group I ($P < 0.05$) and CHD group II ($P < 0.05$). Significant direct correlations between HDLC and apoA-I were found in the pooled CAD group, CAD group II and, CAD-free groups ($r = 0.47$, $P < 0.001$; $r = 0.59$, $P < 0.001$ and $r = 0.51$, $P < 0.01$, respectively). Negative correlations between HDLC and BMI in the pooled CAD group ($r = -0.23$, $P < 0.05$) and between BMI and apoA-I in the CAD-free group ($r = -0.35$, $P < 0.05$) were determined.

The HDLC level <1.29 mmol/l in women was recognized as one of the components of metabolic syndrome (20). The frequency of patients having the HDLC level less than 1.29 mmol/l was as follows: in the CAD-free group – 35.5 percent, in the CAD group I – 50 percent, in the CAD group II – 58.1 percent, in the pooled CAD group – 54.1 percent ($P > 0.05$).

The TG levels were significantly lower in the CAD-free group than in the pooled CAD group, CAD group I and CAD group II ($P < 0.001$). Significant direct correlations of TC level with HDLC and apoA-I were determined in the pooled CAD

group ($r = 0.34$, $P < 0.01$; $r = 0.41$, $P < 0.001$, respectively). The CAD group I showed TC level correlations with apoA-I, apoB and apoB/apoA-I ratio ($r = 0.43$, $P < 0.02$; $r = 0.64$, $P < 0.001$ and $r = 0.37$, $P < 0.05$, respectively). In the CAD group II there were correlations between TC and HDLC ($r = 0.42$, $P < 0.02$) as well as between TC and apoA-I ($r = 0.41$, $P < 0.05$, respectively).

No differences in apoB level among all CAD groups as well as between the CAD-free group and CAD groups were determined ($P > 0.05$). The direct correlations between TC and apoB in all groups of patients were found statistically significant ($r = 0.65$, $P < 0.001$ in the pooled CAD group; $r = 0.64$, $P < 0.001$ in the CAD group I; $r = 0.69$, $P < 0.001$ in the CAD group II and $r = 0.71$, $P < 0.001$ in the CAD-free group).

The apoB/A-I ratio was found similar in all groups ($P > 0.05$). A statistically significant negative correlation between the apoB/A-I ratio and HDLC in CHD-free patients was determined ($r = -0.37$, $P < 0.05$). The apoB/A-I ratio significantly correlated with TG level in the pooled CAD group, CAD group I and CAD-free group ($r = 0.27$, $P < 0.05$; $r = 0.38$, $P < 0.05$ and $r = 0.39$, $P < 0.05$, respectively).

DISCUSSION

In 2001, the U.S. Institute of Medicine recommended to account for gender differences with the aim of improving the health of women. Identification of gender distinction in disease prevalence, course and outcomes can result in favorable differentiations to address problems specific to women (13). The average annual increases in hospitalization for heart failure in the U.S.A. were greater for women than for men between 1990 and 1999 (14).

Investigations suggest that approximately half of women with chest pain and no significant angiographically documented CAD have evidence of coronary microvascular dysfunction, and traditional risk factors for atherosclerosis are not associated with damaged coronary microcirculation in women with chest pain in the absence of obstructive CAD (15). Postmenopausal women who do not use hormone replacement therapy are more prone than hormone users to have microvascular dysfunction (16). On the other hand, coronary artery luminal potency usually is unaffected until the growing plaque occupies 40 percent of the vessel's cross sectional area. This outward displacement, which was named "arterial remodeling", explained why high-risk lesions often went unrecognized angiographically (17). The prevalence of coronary artery remodeling and coronary microvascular dysfunction as well as the pathophy-

siology of the relationship of these conditions in women with chest pain in the absence of obstructive CHD are not elucidated (15, 18).

In the current study, we report an association between decreased blood serum apoA-I concentrations and increased TG levels in female groups with angiographically defined CAD. Our data show significant negative correlations between HDLC and BMI in the pooled CAD group and between BMI and apoA-I in the CAD-free group. BMI was found to be a strong predictor of and to exert an independent additive effect on apoA-I concentration in men and women. The age and BMI of all our study groups were similar, thereby, the observed differences of apoA-I, TG levels were not related with a possible influence of them depending on weight or hormonal status (all women were postmenopausal). According to the current guidelines, our study cohort comprised overweight women (BMI of 25.0 to 29.9) both in having angiographically determined CAD or CAD-free groups (19). The role of possible metabolic disorders indirectly shows increased TG levels in CAD groups of women. In our study TG levels were significantly higher in all CAD groups compared to the CAD-free group. It is a well known fact that elevated triglycerides are a more potent predictor of cardiovascular risk in women than in men (6).

Increases in HDLC are in fact independently correlated with coronary angiographic and clinical benefit (18). Our study did not reveal statistically significant differences in HDLC levels between the angiographically defined CAD-free group and the CAD groups of women. The National Cholesterol Education Program Adult Treatment Panel III shows that HDLC <1.29 mmol/l in women is one of the components of metabolic syndrome (20). Our data reflect a tendency to an increased frequency of individuals with HDLC <1.29 mmol/l, but no significant differences in the mentioned frequency between the groups were found. Further studies are needed to confirm such possible relationship.

Although the CAD-free and CAD groups had the same BMI, significant differences in blood serum TG levels were found. These data could indicate that CAD groups could be related with particular metabolic disorders. Overweight, insulin resistance cause other serious metabolic problems, especially high TG levels, linked with elevated concentrations of highly atherogenic triglyceride-rich lipoprotein remnants. HDLC itself is formed from components of chylomicron and VLDL metabolism as one of the several pathways that modulate HDL, apoA-I concentrations linked to a high TG and a decreased HDLC concentration (18). The mentioned metabolic disorders could be one of the rea-

sons why our CAD patients had significantly lowered blood serum apoA-I levels. BMI is inversely related with the blood serum apoA-I level (21).

In women, HDLC particle size was found inversely correlated with triglycerides and BMI (22). HDL particles are heterogeneous in nature, however, all of them contain apoA-I, and a low plasma level of apoA-I is a known indicator of increased CAD risk in both women and men (10, 23). The known inherited tendency to early atherosclerosis is related with a low serum level of apoA-I (23). ApoA-I activates the metabolism of cholesterol ester stores in macrophages, leading to the reduction of cholesterol content of this major cell type in atherosclerosis (24). A-I is associated with the severity of coronary artery disease (25, 26). ApoA-I is mainly associated with HDL particles, but circulating free apoA-I is also present at low concentrations (27). It may have antioxidant, anti-thrombotic and anti-inflammatory properties which could have important anti-atherogenic effects (26).

Increased apoB and low apoA-I blood serum concentrations elicit cholesterol accumulation in arterial wall cells and the early formation of atherosclerotic plaques (22, 28). Our earlier studies showed that increased apoB and lower apoA-I levels in blood serum were important markers in the development of coronary arterial atherosclerosis in both study groups – young and elderly men ill with coronary artery disease (8). Our data support other results that the diagnostic significance of apoA-I is higher than of HDLC in the evaluation of coronary lesion severity (29). We did not find any differences in apoB levels between the CAD-free and the CAD groups. To evaluate the significance of apoB as an atherogenic factor for CAD women groups, a comparative analysis involving a control group of healthy normal-weight women should be performed.

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VAINIKINIŲ ARTERIJŲ ATEROSKLEROZE SERGANČIŲ MOTERŲ LIPIDŲ IR APOLIPOPROTEINŲ KONCENTRACIJA KRAUJO SERUME

S a n t r a u k a

Darbo tikslas. Nustatyti moterų, sergančių vainikinių arterijų (VA) ateroskleroze, kraujo serumo lipidų ir apolipoproteinų (apo) kiekio pokyčius.

Tyrimo medžiaga ir metodai. Tirtos 92 moterys, kurioms atlikta diagnostinė koronarografija. Išmatuotas tiriamųjų ūgis, svoris, apskaičiuotas kūno masės indeksas (KMI). Ryte prieš koronarografiją nevalgius paimti kraujo serumo mėginiai ir ištirta bendro cholesterolio (BC), didelio tankio lipoproteinų cholesterolio (DTLC) ir trigliceridų (TG) koncentracija. Tuose pačiuose mėginiuose turbidimetriniu metodu, naudojant Spinreact (Spinreact AA, Sant Esteve De Bas, Ispanija) monokloninius antikūnus

prieš apo, ištirtas apo A-I ir B kiekis. Mėginiai iki apo tyrimų buvo laikomi užšaldyti -40°C . Pagal koronarografijos duomenis tiriamosios buvo suskirstytos į tris grupes: vieną grupę sudarė moterys, kurioms koronarografija nenustatyta VA pakitimų ($n = 31$, KMI $29,5 \pm 4,5$; vidutinis amžius $63 \pm 7,0$ metai), I VA aterosklerozės grupei priskirtos moterys, kurioms rasta pavienių plokštelių vienoje arba dviejose VA, siaurinančių spindį daugiau nei 50% ($n = 30$, KMI $31,0 \pm 5,3$; vidutinis amžius $66 \pm 7,6$), II VA aterosklerozės moterų grupės atstovėms rastos didesnės nei 50% stenozės trijose ir daugiau VA, o kartais ir kairiosios VA kamiene ($n = 31$, KMI $30,4 \pm 4,6$; vidutinis amžius $66 \pm 7,1$). Abi VA aterosklerozės grupės sujungtos į bendrą grupę ($n = 61$), norint palyginti turimus duomenis su nepakitusių VA grupe.

Rezultatai. Tiriamųjų amžius ir KMI grupėse nesiskyrė ($P > 0,05$). BC ir DTLC koncentracijų skirtumai, palyginus nepakitusių VA grupę su I, II bei bendra VA aterosklerozės grupėmis, buvo statistiškai nereikšmingi ($6,7 \pm 1,18$ lyginant su $6,12 \pm 1,58$, $6,53 \pm 1,23$ ir $6,33 \pm$

$1,42$ mmol/l; $P > 0,05$; ir $1,36 \pm 0,28$ lyginant su $1,25 \pm 0,20$, $1,28 \pm 0,36$ ir $1,27 \pm 0,29$ mmol/l; $P > 0,05$, atitinkamai). ApoA-I kraujo serumo koncentracija nepakitusių VA grupėje buvo gerokai didesnė nei I, II ir bendroje VA aterosklerozės grupėje ($1,26 \pm 0,26$ lyginant su $1,13 \pm 0,14$, $1,14 \pm 0,16$ ir $1,13 \pm 0,15$ g/l; $P < 0,05$, atitinkamai). TG kiekis nepakitusių VA grupės moterims buvo daug mažesnis nei I, II ir bendros VA aterosklerozės grupių moterims ($1,34 \pm 0,73$ lyginant su $2,2 \pm 0,99$, $1,82 \pm 0,83$ ir $2,0 \pm 0,92$ mmol/l; $P < 0,02$, atitinkamai). ApoB koncentracija, ApoB/A-I santykis visų grupių moterų buvo vienodas ($P > 0,05$).

Išvados. Vertinant VA aterosklerozės riziką moterims, apoA-I diagnostinė reikšmė yra didesnė nei DTLC ir BC. Nepakitusių VA grupės ir VA aterosklerozės grupių TG koncentracijos skirtumai patvirtina svarbų TG metabolinių sutrikimų vaidmenį moterų VA aterosklerozės raidoje.

Raktažodžiai: moteriškoji lytis, vainikinių arterijų aterosklerozė, apolipoproteinas A-I, trigliceridai