Original article

Clinical significance of analysis of the level of blood fat, CRP and hemorheological indicators in the diagnosis of elder coronary heart disease

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A R T I C L E I N F O

A B S T R A C T

Objective: To investigate the levels of blood fat, C-reactive protein (CRP) and hemorheological indicators in the elder patients with coronary heart disease (CHD), so as to provide evidence for prospective study and treatment of elder CHD.
Methods: We collected the clinical data of 127 elder CHD patients who admitted to this hospital between July 2016 and December 2017 to detect the levels of blood fat, CRP and hemorheological indicators.
Results: In elder CHD patients, levels of the total cholesterol (TC), triglyceride (TG) and low density lipoprotein cholesterin (LDL-C) were significantly higher than the normal reference, and comparison with the control group also showed significant increases ($p < 0.01$); average levels of the high-density lipoprotein cholesterin (HDL-C), phospholipid (PL), lipoprotein a [LP (a)] and free fatty acid were in the range of normal reference. Abnormal levels of TC, TG, LDL-C and HDL-C were identified in 59.06%, 58.27%, 51.18% and 18.11% of the elder CHD patients, most of which were concomitant with obesity or hypertension, and levels of these indicators were significantly higher than those in the control group with statistically significant differences ($p < 0.01$). Comparisons of the age, gender distribution, hypotension, exercise and sleep showed that differences had no statistical significance ($p > 0.05$). In comparison with the control group, the levels of CRP, the whole blood viscosities at high and low shears, plasma viscosity, hematocrit value, aggregation index and rigidity index of red blood cells (RBC) were all higher than those in the control group, and the differences had statistical significance ($p < 0.01$). However, the erythrocyte sedimentation rate (ESR), deformity index of RBC, blood flow rates in the bilateral middle cerebral arteries (MCA), anterior cerebral arteries (ACA), terminal internal carotid artery (TICA), posterior cerebral arteries (PCA), vertebral arteries (VA) and basilar artery (BA) were significantly lower than those in the control group, and the differences had statistical significance ($p < 0.05$ or 0.01).
Conclusion: In elder CHD patients, anomaly is mainly seen in levels of TC, TG and LDL-C with concentrated, adhesive and aggregating blood.
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1. Introduction

Increasing trends have been noted in the morbidity rate and mortality rate of the cardiovascular diseases, among which hyperlipemia and inflammatory responses play critical roles in the development of coronary atherosclerotic cardiopathy, also known as coronary heart disease (CHD) (Assmann et al., 1999; Finegold et al., 2012). Research has shown that total cholesterol (TC), triglyceride (TC), low-density lipoprotein cholesterin (LDL-C) and C-reactive protein (CRP) are major factors contributing to the

increase in the prevalence of CHD, while the high-density lipoprotein cholesterin (HDL-C) acts as a major factor in decreasing the prevalence of CHD (Cullen et al., 1998; De-Feyter, 1999). Thus, we aimed to figure out the clinical significance of evaluating the levels of blood fat, CRP and hemorheological indicators in diagnosis and treatment of CHD through measurements of these indicators in 139 CHD patients and 139 healthy volunteers who attended the physical examination in this hospital, and the detailed information of this study is reported as follows.

2. Material and methods

2.1. Subjects

According to the corresponding diagnostic criteria, inclusive criteria and exclusive criteria, 139 elder CHD patients who visited the clinic or were admitted to this hospital between July 2016 and December 2017 for treatment were enrolled in this study. Among CHD patients, the age ranged from 56 to 87 years old with an average of (61.2 ± 15.4) years old; there were 78 males (55.91%) aged between 56 and 79 years old with an average of (59.8 ± 14.6) years old; there were 61 females (44.09%) aged between 58 and 87 years old with an average of (62.7 ± 14.1) years old. CHD diagnoses were made according to the diagnostic criteria of atherosclerosis vascular diseases in coronary artery or other arteries stipulated by American college cardiology (ACC) and American Heart Association (AHA) in association with National Heart, Lung and Blood Institute (NHLBI). Before study, patients or their guardians signed the informed consents. In the same period, we selected 139 elder volunteers who attended physical examination in this hospital as the healthy control. Among these volunteers, the age ranged from 56 to 87 years old with an average of (61.2 ± 15.4) years old; there were 78 males (55.91%) aged between 56 and 79 years old with an average of (59.8 ± 14.6) years old; there were 61 females (44.09%) aged between 58 and 87 years old with an average of (62.7 ± 14.1) years old. No statistical significance was noted in the differences of age and gender between two groups $(p > 0.05)$, suggested that those data were comparable. In subject enrollment, patients with inadequate data, cardiac shock, tachycardia, arrhythmia, valvular diseases, peripheral vascular diseases, solid tumors, other systemic diseases or severe mental disorders were excluded. Meanwhile, for measurement of indicators of blood fat, we excluded those with secondary dyslipidemia caused by primary dyslipidemia, nephrotic syndrome, mellitus diabetes, Cushing syndrome, liver and gallbladder diseases with cholestasis, biliary cirrhosis, pancreatitis or medication.

2.2. General data

Through questionnaire, review of case history, treatment in hospital or re-examination at clinic, follow-up using telephone or correspondence, data acquisition was done by the medical professionals that had been trained specifically. Survey was carried out from the age, gender, height, blood pressure, diet, alcohol intake history, exercise, sleep time and familial history.

2.3. Measurement of blood fat, CRP and hemorheological indicators

One day before measurement, all subjects were required to take bland diet and fast for 12 h or longer, and in the morning of the next day, 5 mL of fasting venous blood was collected and divided into two samples. One sample was placed in an incubator at 37 °C for 1 h followed by preservation at 4 °C refrigerator overnight, and centrifugation at 3000 r/min for 10 min, and the serum was collected and preserved at 4 °C. At the same time, anti-coagulation treatment was performed for the other sample with EDTA, followed by measurement of hemorheological indicators at 4 °C. Using enzyme method, we detected the levels of total cholesterol (TC), triglyceride (TG), low-density lipoprotein cholesterin (LDL-C), high-density lipoprotein cholesterin (HDL-C), phospholipid (PL), lipoprotein a [LP (a)], free fatty acid (FFA) and CRP in serum. Anti-coagulant blood sample was used for determining the whole blood viscosity at high and low shears, aggregation index, deformity index and rigidity index of red blood cell (RBC), plasma viscosity and hematocrit value (Precil LBY-N6 Compact for whole blood viscosity, plasma viscosity, aggregation index, rigidity index and deformity index of RBC, and high-speed micro-centrifugation method for hematocrit value). Simultaneously, EMS-9 transcranial doppler (TCD) was used to detect the blood flow rates in bilateral middle cerebral arteries (MCA), anterior cerebral arteries (ACA), terminal internal carotid arteries (TICA), posterior cerebral arteries (PCA), vertebral arteries (VA) and basilar arteries (BA).

2.4. Diagnostic criteria of dyslipidemia

Diagnostic criteria in *Guidelines of Prophylaxis and Treatment of Adult Dyslipidemia in China* (2007 Edition) [3]: hypercholesterolemia, $TC \geq 5.18$ mmol/L; hypertriglyceridemia, $TG \geq 1.70$ mmol/L; high LDL-C, LDL-C ≥ 3.37 mmol/L; low HDL-C, HDL-C < 1.04 mmol/L.

2.5. Statistics

SPSS 19.0 software was used for data analysis. Measurement data were presented in mean ± standard deviation $(\bar{x} \pm s)$, and t test was performed for intergroup comparison. Chi-square test was performed for comparison of the enumeration data. $\alpha = 0.05$ was set as the inspection level.

3. Results

3.1. General data of the subjects in two groups

No statistical significance was identified in comparisons of the age and gender between two groups $(p > 0.05)$, suggesting that data were comparable (Table 1).

3.2. Comparisons of the levels of blood fat and CRP between two groups

In all elder CHD patients, average levels of TC, TG and LDL-C were higher than the normal reference range, and other indicators were within the normal range. In comparison with the control group, average levels of TC, TG, LDL-C and CRP in elder CHD patients were significantly elevated, and the differences had statistical significance $(p < 0.01)$. No statistically significant differences were identified in comparisons of the average levels of HDL-C, PL, LP (a) and FFA between two groups $(p > 0.05;$ Table 2).

Table 1
General data of the subjects in two groups $(\bar{x} \pm s)$.

Item	Control group	CHD group
Case (n)	139	139
Gender (male/female)	75/64	78/61
Age (years)	55–86 (60.4 ± 11.3)	56–87 (61.2 ± 15.4)

Table 2
Comparisons of the levels of blood fat and CRP between two groups ($\bar{x} \pm s$, n = 139).

Group	TC (mmol/L)	TG (mmol/L)	LDL-C (mmol/L)	HDL-C (mmol/L)	PL (mmol/L)	LP (a) (mmol/L)	FFA (mmol/L)	CRP (mg/L)
Control	4.55 ± 0.54	1.49 ± 0.26	2.66 ± 0.44	1.21 ± 0.11	53.00 ± 10.14	0.29 ± 0.03	0.64 ± 0.09	4.03 ± 0.53
CHD	5.24 ± 0.51	1.86 ± 0.38	3.40 ± 0.47	1.17 ± 0.13	51.91 ± 8.94	0.28 ± 0.03	0.67 ± 0.10	4.21 ± 0.57
t	−11.0584	−7.9117	−18.0927	0.8126	0.2615	0.1985	−0.5842	−4.2288
p	<0.01	<0.01	<0.01	0.0543	0.3647	0.0531	0.0891	<0.01

Note: TC: total cholesterol; TG: triglyceride; LDL-C: low-density lipoprotein cholesterin; HDL-C: high-density lipoprotein cholesterin; PL: phospholipid; LP (a): lipoprotein a; FFA: free fatty acid; CRP: C-reactive protein.

3.3. Incidence rate of dyslipidemia in elder CHD patients

Incidence rates of anomalies in levels of TC, TG, LDL-C and HDL-C were higher in the elder CHD patients than those in the control group, and the differences had statistical significance ($p < 0.01$, Table 3). Obesity was concomitant with 77.33% of patients with abnormal TC levels, 90.54% with abnormal TG levels, 93.85% with abnormal LDL-C levels and 80.61% with abnormal HDL-C levels; patients with hypertension accounted for 65.33%, 93.24%, 87.69% and 90.30% in patients with abnormal TC, TG, LDL-C and HDL-C levels, respectively. Thus, the incidence rate of dyslipidemia in elder CHD patients with obesity or hypertension was significantly higher than those of their counterparts in the control group ($p < 0.01$), but there was no statistically significant difference in comparison of the incidence rate of hypotension, exercise time and sleep time between these two groups ($p > 0.05$). In addition, a higher detection rate was identified in patients with history of smoking, alcohol intake, little exercise and poor sleep. From Table 4, in two groups, incidence rates of anomalies in levels of TC, LDL-C and HDL-C in males were higher than the females, but as for TG, incidence rate of abnormal level of TG in females was higher than the males. In terms of age, the number of patients with anomalies in levels of TG, LDL-C and HDL-C was increased against the age, but the total different trend was identified in males with abnormal level of TC. However, there was no statistically significant difference in comparison between two groups ($p > 0.05$).

3.4. Measurement of the hemorheological indicators in two groups

In the elder CHD patients, the whole blood viscosities at high shear [(5.21 ± 0.54) mPa s *vs.* (4.17 ± 0.47) mPa s] and low shear [(10.86 ± 1.00) mPa s *vs.* (8.65 ± 0.80) mPa s], plasma viscosity [(2.39 ± 0.35) mPa s *vs.* (1.78 ± 0.26) mPa s] and hematocrit [(0.60 ± 0.09) L/L *vs.* (0.44 ± 0.03) L/L] were higher than those in the control group, while the ESR in the CHD patients was significantly lower than that in the control group [(17.51 ± 3.22) mm/h *vs.* (27.92 ± 2.96) mm/h], and the differences had statistical significance ($t = −5.748, −8.931, −6.103, −3.114$ and $16.855, p < 0.01$). In the elder CHD patients, the aggregation index and rigidity index were also significantly elevated in comparison with those in the control group [(2.59 ± 0.45) *vs.* (2.06 ± 0.39); (5.76 ± 0.64) *vs.* (4.88 ± 0.51)], but the deformity index was significantly lower than that in the control group [(0.74 ± 0.17) *vs.* (0.78 ± 0.13)], and the difference had statistical significance ($t = −3.317, −6.051$ and $1.774; p < 0.01$ or 0.05).

3.5. Measurement of blood flow rate in two groups

In comparison with the control group, the average MCA, ACA, TICA, PCA, VA and BA in the elder CHD patients were significantly lower than those in the control group, and the difference had statistical significance ($p < 0.01$ or 0.05; Table 5).

Table 3
Distribution of the detection rates of different types of dyslipidemia in two groups [n (%)].

Type	Group	Dyslipidemia	Obesity	Hypertension	Hypotension	Smoking	Alcohol intake	Little exercise	Poor sleep
Abnormal TC	Control	22(15.83)	3(13.64)	5(22.73)	1(4.55)	4(18.18)	15(68.18)	22(15.83)	3(13.64)
	CHD	82(58.99)[b]	63(76.83)[b]	53(64.63)[b]	17(20.73)	38(46.34)[a]	68(82.93)	82(58.99)[b]	63(76.83)[b]
Abnormal TG	Control	28(20.14)	12(42.86)	7(25.00)	1(3.57)	10(35.71)	16(57.14)	28(20.14)	12(42.86)
	CHD	81(58.27)[b]	73(90.12)[b]	76(93.83)[b]	17(20.99)	45(55.56)	78(96.30)[b]	81(58.27)[b]	73(90.12)[b]
Abnormal LDL-C	Control	6(4.32)	2(33.33)	1(16.67)	1(16.67)	3(50.00)	5(83.33)	6(4.32)	2(33.33)
	CHD	71(51.08)[b]	67(94.37)[b]	62(87.32)[b]	30(42.25)	48(67.61)	67(94.37)	71(51.08)[b]	67(94.37)[b]
Abnormal HDL-C	Control	10(7.19)	2(20.00)	3(30.00)	3(30.00)	1(10.00)	6(60.00)	10(7.19)	2(20.00)
	CHD	25(17.99)[a]	20(80.00)[b]	23(92.00)[b]	8(32.00)	9(36.00)	22(88.00)	25(17.99)[a]	20(80.00)[b]

[a] $p < 0.05$.
[b] $p < 0.01$ *vs.* control group.

Table 4
Detection of the dyslipidemia in subjects with different age in different gender in two groups.

Type	Group	Total detection rate		50–59 years old		60–69 years old		70 or older	
		Male	Female	Male	Female	Male	Female	Male	Female
Abnormal TC	Control	12(54.55)	10(45.45)	6(27.27)	1(4.55)	4(18.18)	3(13.64)	2(9.10)	6(27.26)
	CHD	44(53.66)	38(46.34)	16(19.51)	16(19.51)	15(18.29)	11(13.41)	12(14.63)	11(13.41)
Abnormal TG	Control	12(42.86)	16(57.14)	2(7.14)	4(14.29)	4(14.29)	4(14.29)	6(21.43)	8(28.56)
	CHD	37(45.68)	44(54.32)	10(12.35)	11(13.58)	11(14.81)	12(16.05)	16(18.52)	21(24.69)
Abnormal LDL-C	Control	3(50.00)	3(50.00)	0(0.00)	0(0.00)	1(16.67)	2(33.33)	2(33.33)	1(16.67)
	CHD	38(53.52)	33(46.48)	9(12.68)	8(12.68)	13(18.31)	13(18.31)	16(22.53)	12(15.49)
Abnormal HDL-C	Control	5(55.56)	4(44.44)	2(22.22)	1(11.11)	0(0.00)	1(11.11)	3(33.33)	2(22.22)
	CHD	14(56.00)	11(44.00)	4(16.00)	3(12.00)	3(12.00)	3(12.00)	7(28.00)	5(20.00)

Table 5
Measurement of blood flow rate in two groups.

Group	Case (n)	MCA	ACA	TICA	PCA	VA	BA
Control	139	40.02 ± 5.08	49.83 ± 5.14	34.15 ± 4.88	39.76 ± 3.08	32.71 ± 3.95	33.11 ± 3.48
CHD	139	32.73 ± 3.29	39.64 ± 3.24	32.94 ± 3.7	32.94 ± 4.07	24.71 ± 4.72	24.16 ± 4.53
t		11.8532	18.4828	5.1109	8.9905	12.0058	9.1032
p		<0.01	<0.01	<0.05	<0.01	<0.01	<0.01

Note: MCA, middle cerebral artery; ACA, anterior cerebral artery; TICA, terminal internal carotid artery; PCA, posterior cerebral artery; VA, vertebral artery; BA, basilar artery.

4. Discussion

Coronary heart disease, as one of the most frequent cardiovascular diseases in clinical practice, is a kind of inflammatory responses in vascular endothelium caused by atherosclerosis of coronary artery. Obstruction, insufficient blood and oxygen supply in the coronary artery lead to decline or failure in the function of myocardium, which is also regarded as one of the major factors of death (Lakka et al., 2002; Mackenbach et al., 2000; Parker et al., 2003).

Clinical studies have shown that dyslipidemia is a critical factor contributing to the development of CHD, severely affecting the incidence rate and mortality rate of CHD. Generally, dyslipidemia is characterized by the anomaly in metabolism or transportation of fat, which usually results in the deposition of fat in the coronary artery, thereby giving rise to the inflammatory responses, immune responses, CHD, or even exacerbation in disease condition. CHD is correlated with a variety of indicators in blood fat, including TC, TG, HDL-C and LDL-C, and disorder in fat metabolism and increased content of blood fat are contributing to the development of CHD. Variation in TC serves as one of the major indicators of fat metabolism with a normal range from 2.86 to 5.98 mmol/L (Laaksonen et al., 2002). TG is synthesized by human fat tissues and livers, and delivered to the fat tissues, with a normal range from 0.22 to 1.21 mmol/L. HDL-C can transport the cholesterol surrounding the tissues, and by HDL-C, cholesterol can be transformed into the bile acid or excreted through bile. Coronary arteriography reveals a negative correlation between the content of cholesterol in HDL and the stenosis of lumen in coronary artery (Lawlor et al., 2002; Silventoinen et al., 2003). Thus, HDL is also a kind of protective factors in CHD tissues that can resist the atherosclerosis of coronary artery, and its normal range is set as 0.9–2.19 mmol/L. As for LDL-C, any increase in the level of LDL-C in blood would lead to accumulation of LDL-C in the lining of arteries, thus promoting the spasm of coronary artery, atherosclerosis or even obstruction in vessels. Normally, the level of LDL should be lower than 3.12 mmol/L, and for any case with LDL exceeding the normal value, it indicates severe damage to the cardiovascular system. Thus, LDL is a kind of destructive factor in CHD tissues (Parker et al., 2003).

A report of Multiple-center collaborative group of hypercholesteremia in China showed that variations in the diet structure and life style in China has resulted in an increasing trend in the prevalence of hyperlipemia (Hidvegi et al., 2001), and with an increase in age, the incidence rate is also augmented in the dyslipidemia (Park et al., 2003). In this study, the average levels of TC, TG and LDL-C in elder CHD patients were higher than the normal range, and compared to the control group, significant increases were also noted in the levels of TC, TG and LDL-C, while other indicators of blood fat were within the normal reference range.

CRP, a reactive protein formed in response to the acute event, is a major marker in diagnosis of severe infection, and the level of CRP in serum is a non-specific clinical indicator for injuries to cells or tissues; generally, CRP level is not higher than 10 mg/L. In recent years, the wide application of the level of CRP in serum provides critical evidence in clinical diagnosis of CHD. Studies also showed that in CHD patients, inflammatory reactions, in addition to lipid accumulation, are also contributing to the development of atherosclerosis of coronary artery, which shows an immediate correlation between the atherosclerosis of coronary artery and the vascular endothelial inflammation (Wannamethee and Shaper, 2001; Yoo et al., 2004). Atherosclerosis of coronary artery gives rise to the inflammation and an increase in the level of CRP, indicative the potential factor inducing the CHD. CRP can accelerate not only the entrance or adhesion of white cells in or on the vascular wall through regulating the expressions of arteriosclerosis-related factors, but also the oxidation of LDL-C through chemotaxis of monocyte to facilitate the transformation of macrocyte into the foam cells by absorbing the LDL, so as to develop the arteriosclerosis (Grundy et al., 2004). In this study, the level of CRP in the elder CHD patients was significantly higher than that in the control group.

Hemorheology is critical in evaluating the development and progression of diseases. Due to an increase in age, hyperviscosity emerges in response to the aging and decline in organs or tissues, which can induce the anomaly in the vascular morphology and hemorheology in the microenvironment, thus affecting the physiological function (Alnaim and Almaz, 2017; Eseyin et al., 2018; Gao et al., 2017; Godsland et al., 1998; Sorlie et al., 1999; Wang et al., 2018). A great number of experimental and clinical studies have conformed the interaction between the geriatric diseases and hyperviscosity. In this study, the whole blood viscosities at high and low shears, plasma viscosity, hematocrit, aggregation index and rigidity index of RBC were all higher than those in the control group, while the ESR and deformity index of RBC were lower. A high blood viscosity definitely slow down the blood flow rate, giving rise to the dysfunction of blood circulation, insufficient blood perfusion in tissues, hypoxemia, hypoxia, dysregulation in metabolism or dysfunctions. In this study, results also showed that in elder CHD patients, the average blood flow rates in MCA, ACA, TICA, PCA, VA and BA were significantly lower than those in the control group, suggesting that the blood flow rate in elder CHD patients was decreased for the condensed and thick blood.

In conclusion, pathogenesis and incidence rate of CHD are closely correlated with the levels of blood fat, CRP and hemorheological indicators, and medical professionals should pay attention to these indicators, so as to prevent the atherosclerosis of coronary artery, increase the clinical diagnostic rate of CHD patients and provide critical evidence for prophylaxis and treatment of CHD.

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