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Correlation study on waist circumference-triglyceride (WT) index and coronary artery scores in patients with coronary heart disease

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Abstract. – OBJECTIVE: Coronary disease is analyzed through common lipid profiles, but these analyses fail to account for residual risk due to abdominal weight and elevated TG levels. We aimed to investigate the relationship between the waist circumference × triglyceride index (WT index) and the Coronary Artery Score (CAS) in patients with coronary heart disease.

PATIENTS AND METHODS: 346 patients in our Cardiology Department were recruited from September 2007 to August 2011 and divided into two groups according to whether the patients presented with metabolic syndrome. We performed coronary angiography using the standard Judkins method. The severity of coronary artery stenosis and the CAS were calculated and analyzed with a computerized quantitative analysis system. The signs index, which includes the body mass index (BMI), waist circumference, hip circumference, waist-hip-ratio, and waist-height-ratio, the blood glucose and blood lipid index of all the patients were collected and used to calculate the WT index (waist circumference x triglyceride index.

RESULTS: We performed a correlative analysis with age, gender, body mass index, blood glucose and blood lipid, blood pressure and other risk indicators of all patients as the dependent variables and the CAS as the independent variable. We show that the CAS is positively correlated to the WT index. Several lipid profiles and waist circumference were significantly associated with the CAS.

CONCLUSIONS: The WT index is correlated to the CAS and is a good predictor for the development of coronary artery disease; it can be applied in the clinic for early intervention in populations at risk for coronary heart disease.

Key Words:
Coronary disease, Metabolic syndrome X, Coronary Artery Score, WT index.

Introduction

A Chinese cohort study showed that the yearly standardized incidence rate of cardiovascular disease is higher in patients who have metabolic syndrome (MS) than in those without MS[1,2]. MS is the most important predictive factor for the occurrence of cardiovascular disease and it significantly increases the mortality rate in coronary heart disease (CHD) patients. Even after high-dose potent statin therapy to lower cholesterol levels, CHD patients with MS still face a high residual risk of CHD[3], of which the increase of triglycerides (TG) and the lowering of high density lipoprotein cholesterol are the main dyslipidemia phenotypes[4]. Additionally, excessive waist circumference (WC) is an independent risk factor for cardiovascular disease and often manifests as abnormal lipid metabolism resulting in higher TG and lower high density lipoprotein cholesterol, which are the important components of the residual risk of cardiovascular disease[5]. We hypothesize that the combination of WC and TG in a waist circumference × triglyceride index (WT index) would be a better indicator of the risk of a cardiovascular event in CHD patients. Our rationale to introduce the WT index in the comprehensive evaluation of abdominal obesity and hypertriglyceridemia is based on the following factors: first, the accumulation of visceral adipose tissue can be roughly estimated by measuring the WC[6]; second, TG levels can indirectly reflect the level of low-density lipoprotein cholesterol[7,8]. Here, we investigate the relationship between the coronary artery score (CAS) and the WT index of CHD patients, and elucidate the influence of the WT index on CHD.

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Patients and Methods

Patients

We analyzed the data from 364 cases of CHD patients admitted to the Cardiology Department of Second Affiliated Hospital of Kunming Medical University between September 2007 and August 2011. We categorized them according to whether they presented with MS: those with MS, the CHD-MS group, and those without MS, the CHD-nMS group. In the CHD-MS group, there were 265 patients (211 males, 54 females) aged from 32 to 85 (mean 62.10 ± 10.76); and in the CHD-nMS, there were 81 patients (65 males, 16 females) aged from 36 to 79 (mean 63.54 ± 11.20).

CHD diagnostic criteria

We consulted related guide documentation[9-11], and confirmed through coronary arteriography that the severity of stenosis of one or more coronary arteries was ≥ 50%[12]. We included cases of chronic stable angina (including latent CHD and cardiac syndrome X) and acute coronary syndrome.

MS diagnostic criteria

Based on the MS diagnostic criteria[13], we diagnosed patients as presenting with MS if they possessed the following three or more symptoms:

- obesity: male WC > 90 cm; female WC > 80 cm; or a body mass index ≥ 25 kg/m^2;
- blood TG ≥ 1.70 mmol/L;
- blood high density lipoprotein cholesterol < 1.03 mmol/L;
- blood pressure≥ 130/85 mmHg;
- fasting plasma glucose ≥ 5.6 mmol/L, or 2h after glucose load and blood sugar ≥ 7.8 mmol/L, or having a history of diabetes mellitus.

Exclusion criteria

All patients with serious liver and kidney dysfunction, tumors, acute infection, pancreas and thyroid disorders were excluded from the study.

Data collection

Lipid and glucose measurements

Twenty-four hours following hospitalization, the venous blood was collected from the upper arm of all patients, who had fasted at least 12 hours, to measure the lipid and the blood sugar levels. The lipid parameters monitored (in mmol/L) included total cholesterol, low density lipoprotein cholesterol, high density lipoprotein cholesterol and TG. The low density lipoprotein cholesterol and high density lipoprotein cholesterol levels were tested with a direct one-step reagent (Wako Pure Chemical Industries Ltd., Osaka, Japan). TG levels were determined using GPO-POD reagent (Kehua Company, Shanghai, China). Fasting plasma glucose was determined with glucose oxidase (in mmol/L).

Blood pressure measurement

We measured and calculated the systolic blood pressure, the diastolic blood pressure, the mean artery pressure, the pulse pressure and the pulse pressure index. All pressure parameters are in mmHg except the pulse pressure index. We noted the arterial systolic blood pressure and diastolic blood pressure of every patient during their hospitalization and calculated the average. Based on the peripheral systolic blood pressure and diastolic blood pressure recorded, we calculated the mean artery pressure, pulse pressure and pulse pressure index using the following formulae:

- mean artery pressure = [(2 × diastolic) + systolic]/3;
- pulse pressure = systolic blood pressure – diastolic blood pressure;
- pulse pressure index = pulse pressure / systolic blood pressure.

WC and hip circumference measurement

WC measurements were performed on patients on an empty stomach, with the outer clothing taken off, the body upright, the abdomen relaxed, and the feet separated between 25 to 30 cm, at the lower edge of the lowest rib and the iliac crest along the axillary line. The measuring tape was fixed horizontally on the midpoint of the connection line between the lower edge of the lowest rib and the iliac crest and the value was determined when the patient exhaled. The hip circumference measurement was taken at the same time at the pubic symphysis, by measuring horizontally the largest circumference of the buttocks, with an accuracy of ± 1 cm.

The WT index calculation (in cm.mmol/L)

We used the following formula to calculate the WT index:

- WT = WC (cm) × TG (mmol/L)
- 2.5 Body mass index calculation

We used the following formulae:

- waist-hip-ratio = WC (cm)/hip circumference (cm);
- waist-height-ratio = WC (cm)/height (cm);
- body mass index = weight (kg)/$height^2$ (m^2). All data were measured twice.

Cardiovascular angiography

Left or right cardiovascular angiography was selectively performed with an Advantx single C-arm Cardiovascular Angiography machine (GE Healthcare, Milwaukee, WI, USA) by the standard Judkins method. Four body positions were chosen to perform the left cardiovascular angiography: left anterior oblique 45° + head/foot position 25° to 30°, right anterior oblique 30° + head/foot position 25° to 30°. Three body positions were chosen to perform the right cardiovascular angiography: left anterior oblique 45°, right anterior oblique 30°, anteroposterior + head position 25° to 30°. Other body positions were added when the coronary artery could not be visualized distinctly. Coronary artery scores (CAS) were calculated within the same pathology, using the body position that most significantly showed the lesion. A quantitative computer analysis system was used to analyse the severity of the stenosis of the coronary artery, and the CAS was calculated using Leaman et al CAS method[14]. This method incorporates both the number of coronary lesions and the severity of lesion stenosis; therefore, it accurately describes the severity of the lesions.

Statistical analysis

All the data fit a normal distribution. All data from measurements is presented as ±*s* and differences between groups were analyzed by an independent-sample *t*-test. Count data was analyzed with a Chi-square (χ^2) test. We used Pearson's single factor correlation analysis to determine whether the various cardiovascular risk elements and the CAS were correlated. Parameters that were associated with the CAS ($p < 0.05$) in the single factor analysis were selected for multi-factorial analysis, and the data were fitted to a multiple linear regression model. All data were analyzed statistically with the SPSS 13.0 software package (IBM, Armonk, NY, USA), and $p < 0.05$ was considered statistically significant.

Results

Comparison of baseline characteristics

We determined the baseline for the two groups of patients and found significant differences in the prevalence of hypertension, the WC, hip circumference, waist-hip-ratio, waist-height-ratio, systolic blood pressure, diastolic blood pressure, mean artery pressure, TG, high density lipoprotein cholesterol, fasting plasma glucose, and WT index (Table I). There were no significant differences between the two groups for the remaining indicators (Table I).

Comparison of the coronary artery disease severity

Compared to the CHD-nMS group, the CHD-MS group's rate of frequency of a triple vessel lesion in the coronary artery was higher (p = 0.049), and the CAS was also higher in the CHD-MS group than in the CHD-nMS group (p = 0.043). The differences in double vessel lesion and single vessel lesion of the two groups were not statistically significant ($p > 0.05$) (Table II).

Correlation analysis

We performed a correlation analysis with each CHD patient's age, sex, body mass index, blood glucose and lipid index, blood pressure indicators and other risk factors as independent variables, and the CAS as dependent variable. We found that the CAS is positively correlated with the WT index, WC, pulse pressure, total cholesterol and low density lipoprotein cholesterol (Table III).

Multi-factorial regression analysis

We performed a multi-factorial regression analysis with each indicator correlated with the CAS as an independent variable, and the CAS as the dependent variable. We found that the CAS is significantly correlated with the WT index, pulse pressure and low density lipoprotein cholesterol (Table IV).

Discussion

In this study, we show that the WT index has a significant positive correlation with the CAS. The higher the WT index of the patients, the more severe the coronary lesion. Thus, the WT index can be considered as a predictive indicator of the occurrence and development of CHD. Previous reports have noted simultaneously increased WC and TG, and have engende red the concept of the TG and WC phenotype[7,15-17], and its relationship with each metabolic index in CHD patients and the severity of lesions in the coronary artery. Currently, the two indicators are always analyzed separately in clinical research, and no indicator exists that combines them, so we have proposed the "WT index" in the evaluation of the severity of lesions in the coronary artery. The increase of both indicators at the same time manifests the

Table I. Comparison of baseline characteristics in the two groups of patients.

Item	CHD-MS	CHD-nMS	Statistics	*p* value
Sex (M/F)	211/54	65/16	χ^2=0.015	1.000
Age (years)	62.10±10.76	63.54±11.20	*t*=-1.047	0.296
Smoking rate (%)	53.96%	61.73%	χ^2=1.517	0.251
(smokers/non-smokers)	143/122	50/31		
Prevalence of diabetes mellitus (%)	38.87%	44.44%	χ^2=0.803	0.437
(diabetics/non-diabetics)	103/162	36/45		
Prevalence of hypertension (%)	74.85%	44.44%	χ^2=28.354	0.000
(hypertensive people/non-hypertensive people)	201/64	36/45		
WC (cm)	91.77±7.05	86.75±8.86	*t*=4.892	0.000
hip circumference (cm)	96.33±8.79	93.09±7.53	*t*=2.931	0.004
waist-hip-ratio *	0.96±0.09	0.93±0.05	*t*=2.504	0.013
waist-height-ratio †	0.55±0.04	0.53±0.06	*t*=3.885	0.000
body mass index ‡	25.24±2.95	23.50±2.81	*t*=4.545	0.000
systolic blood pressure (mmHg)	132.39±18.65	125.67±16.94	*t*=2.896	0.004
diastolic blood pressure (mmHg)	80.51±12.29	76.15±10.56	*t*=2.880	0.004
mean artery pressure (mmHg) §	97.80±12.98	92.65±11.64	*t*=3.194	0.002
pulse pressure (mmHg) ‖	51.88±14.72	49.52±12.45	*t*=1.307	0.192
pulse pressure index #	0.39±0.08	0.39±0.06	*t*=-0.250	0.803
TC (mmol/L)	4.62±1.18	4.43±1.06	*t*=1.254	0.211
TG (mmol/L)	2.38±1.66	1.50±0.87	*t*=6.131	0.000
High density lipoprotein cholesterol (mmol/L)	0.92±0.33	1.10±0.33	*t*=-4.251	0.000
Low density lipoprotein cholesterol (mmol/L)	2.87±1.04	2.72±0.89	*t*=1.143	0.254
fasting plasma glucose (mmol/L)	6.37±2.56	5.06±0.91	*t*=6.952	0.000
WT index (cm.mmol/L)	196.62±104.17	128.28±68.82	*t*=6.195	0.000

*waist-hip-ratio = WC(cm)/ hip circumference (cm)
†waist-height-ratio = WC(cm)/height (cm)
‡body mass index =weight (kg)/height^2 (m^2)
§mean artery pressure = (systolic blood pressure +2 × diastolic blood pressure)/3
‖pulse pressure = systolic blood pressure - diastolic blood pressure
#pulse pressure index = pulse pressure / systolic blood pressure

body's dysfunction in metabolizing energy and saving subcutaneous fat, a process known as protective metabolic deposition. Normally, the body rapidly clears excess TG after eating and stores it in the subcutaneous adipose tissue. The impairment of this function manifests as a series of metabolic disorders and abnormalities in the body, such as diabetes mellitus, atherosclerosis, pro-coagulation, pro-inflammation and other clustering phenomena of metabolic abnormalities.

The two main clinical indicators for diagnosing obesity are the BMI, which reflects total body fat,

Table II. Comparison of coronary artery disease severity.

Group	Single vessel lesion	Double vessel lesion	Triple vessel lesion	CAS
CHD-MS group	92 (34.72)	100 (37.74)	73 (27.55)	10.535±7.436
CHD-nMS group	36 (44.44)	33 (40.74)	12 (14.81)	8.688±6.219
Statistics	χ^2=2.518	χ^2=0.237	χ^2=4.157	*t* =2.208
p value	0.117	0.696	0.049	0.043

Table III. Correlation analysis of CAS and selected risk factors.

Item	WT index	WC	Pulse pressure	TC	Low density lipoprotein cholesterol
Correlation coefficient (*r*)	0.253	0.127	0.125	0. 195	0.214
p value	0.000	0.035	0.021	0.000	0.000

Table IV. Multi-factorial regression analysis.

Factors	*t* value	*p* value
WT index	3.281	0.001
Pulse pressure	3.089	0.002
Low density lipoprotein cholesterol	2.889	0.009

and the WC or waist-hip-ratio, which are used to measure the degree of abdominal obesity, as they are good indicators of abdominal fat sedimentation. A meta-analysis to investigate the relationship between the body mass index and the risk of death revealed that the lowest mortality rate was observed when a patient's body mass index is between 22.5 and 25.0 kg/m². When the body mass index is more than 25.0 kg/m², for each additional 5 kg/m² mortality increased by 30%[18]. Obese patients are often associated with various blood lipid and glucose metabolism disorders, the most common of which are an increase in TG and a decrease in high density lipoprotein cholesterol levels. Obese patients with dyslipidemia generally show very low density lipoprotein cholesterol, an increase in TG and total cholesterol, a decrease in high density lipoprotein cholesterol, and an increase in small and dense low-density lipoprotein[19]. Kahn et al[20] analyzed the NHANES III survey data in the US and found that people with high WC and TG have higher levels of fasting insulin and fasting plasma glucose than those with normal WC and TG. They indicated that increased WC and TG reflect excessive lipid accumulation and, therefore, cause metabolic abnormalities. A mild to moderate increase in TG often reflects an increase in chylomicrons and very low density lipoprotein cholesterol remnants and, since, the particles of the remnant lipoprotein become smaller, they may directly cause atherosclerosis. There are also studies suggesting that increased TG are likely to affect the structure of LDL or HDL, thus, resulting in atherosclerosis[13].

Conclusions

We suggest that the WT index can be applied in the clinic for early intervention in people at risk of developing CHD. In this study, we find that the vascular lesions in patients with MS were more severe; thus, clinical intervention is critical to such patients. The applied value of the WT index in MS and CHD patients will need to be assessed in further studies.

Declaration of Funding Interests

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Conflict of Interest

The Authors declare that there are no conflicts of interest.

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