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Ultrasound features of carotid atherosclerosis in patients with coronary heart disease and their correlation with disease severity

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ABSTRACT

Objective: To study the ultrasound features of carotid atherosclerosis in patients with coronary heart disease and their correlation with disease severity. **Methods:** 180 patients with coronary heart disease treated in our hospital between December 2010 and December 2015 were collected as observation group and divided into single-vessel disease group (n=50), double-vessel disease group (n=72) and triple-vessel disease group (n=58) according to the degree of coronary artery stenosis; 50 healthy subjects receiving physical examination in our hospital during the same period were selected as control group. Carotid ultrasound was used to measure carotid atherosclerosis parameters, cardiac color Doppler ultrasound was used to detect cardiac function parameters, enzyme-linked immunosorbent assay (ELISA) was used to detect serum endothelial function indexes, and Pearson test was used to analyze the correlation between carotid ultrasound parameters and the cardiac function as well as endothelial function. **Results:** Carotid ultrasound parameters stiffness (β), elastic modulus (Ep), arterial compliance (AC) and pulse wave velocity (PWVβ) value of observation group were higher than those of control group, and with the increase of coronary artery lesion severity, the changes of β, Ep, AC and PWVβ value increased (P<0.05); cardiac function parameters left ventricular end-diastolic diameter (LVEDD) and left ventricular end-systolic diameter (LVESD) value of observation group were higher than those of control group while left ventricular ejection fraction (LVEF) value was lower than that of control group, and with the increase of coronary artery lesion severity, the changes of LVEDD, LVESD and LVEF value increased (P<0.05); endothelial function indexes endothelin-1 (ET-1) and von willebrand factor (vWF) levels of observation group were higher than those of control group while nitric oxide (NO) level was lower than that of control group, and with the increase of coronary artery lesion severity, the changes of ET-1, vWF and NO levels increased (P<0.05). Carotid ultrasound parameter β, Ep, AC and PWVβ value in patients with coronary heart disease were directly correlated with the levels of cardiac function parameters and endothelial function indexes. **Conclusions:** The ultrasound parameter levels of carotid atherosclerosis in patients with coronary heart disease are directly correlated with the disease severity and can be used as the noninvasive and reliable means for early judgment of the disease.

1. Introduction

Coronary heart disease is the most common clinical cardiovascular disease, and its pathological basis is coronary atherosclerosis and myocardial blood supply decrease. Due to the strong myocardial compensation, most patients do not show obvious clinical symptoms until the coronary artery stenosis is severe, which brings difficulty to the subsequent treatment and prognosis improvement[1,2]. The early diagnosis of coronary heart disease has been the key point of the clinical research, coronary ultrasound angiography is the gold standard for diagnosis of coronary heart disease, but the inspection process is relatively complex, so it is difficult to be popularized as a routine physical examination project. Scholars have found that carotid arteriosclerosis change may appear in early coronary artery lesions in patients with coronary heart disease, and therefore, they propose to use carotid artery examination as an alternative means of early screening for coronary artery disease[3,4]. At present, there is still not much domestic research on coronary heart disease and the severity of carotid atherosclerosis, and in order to further strengthen the theoretical basis of carotid atherosclerosis as the early diagnostic means for coronary heart disease, 180 patients with coronary heart disease and 50 healthy controls in our hospital were specifically

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studied, now reported as follows:

2. Materials and methods

2.1. General information

180 patients with coronary heart disease treated in our hospital between December 2010 and December 2015 were collected as observation group, and the patients understood the research process and signed the informed consent, and were approved by hospital ethics committee. Inclusion criteria: (1) diagnosed with coronary heart disease by coronary angiography and cardiac color Doppler ultrasonography; (2) ≤80 years old; (3) without previous acute myocardial infarction events. Exclusion criteria: (1) with moderate and severe valve disease, myocarditis, hypertrophic cardiomyopathy, dilated cardiomyopathy and other types of heart diseases; (2) with severe liver and kidney dysfunction; (3) associated with systemic infectious diseases; (4) with malignant tumor diseases; (5) with the history of cerebral infarction events within the past 6 months; (6) with blood coagulation dysfunction; (7) dropping out of the research and with incomplete clinical information. 50 healthy subjects receiving physical examination in our hospital during the same period were selected as control group, and they also signed the informed consent.

According to the degree of coronary artery stenosis, the patients were divided into single-vessel disease group (one coronary artery stenosis >50%) (n=50), double-vessel disease group (two coronary artery stenosis >50%) (n=72) and triple-vessel disease group (three coronary artery stenosis >50%) (n=58). Single-vessel disease group included 27 male cases and 23 female cases, they were 46–73 years old, and the body weight was 52–84 kg and (69.25±7.49) kg in average; double-vessel disease group included 40 male cases and 32 female cases, they were 44–75 years old, and the body weight was 51–83 kg and (68.76±7.88) kg in average; triple-vessel disease group included 32 male cases and 26 female cases, they were 43–72 years old, and the body weight was 53–87 kg and (69.87±7.55) kg in average. Control group included 27 male cases and 23 female cases, they were 43–76 years old, and the body weight was 51–82 kg and (67.39±8.45) kg in average. There was no statistical significance in the distribution of baseline information (gender, age and body weight) among groups (P>0.05).

2.2. Carotid ultrasound parameters

The subjects rested quietly for 10 min and took supine position, the diasonograph (Japan's Hitachi group, model Prosound a10) was used to detect bilateral common carotid atherosclerosis extent, and the detected projects included stiffness (β), elastic modulus (Ep), arterial compliance (AC) and pulse wave velocity (PWVβ).

2.3. Cardiac function parameters

Cardiac color Doppler ultrasound was used to determine the left cardiac function parameters of the research subjects, which were specifically as follows: left ventricular end-diastolic diameter (LVEDD), left ventricular end-systolic diameter (LVESD) and left ventricular ejection fraction (LVEF).

2.4. Endothelial function

2ml of fasting peripheral venous blood was collected from the research subjects, and the specified steps in ELISA kits were followed to determine the endothelial function indexes in it, including endothelin-1 (ET-1), nitric oxide (NO) and von willebrand factor (vWF).

2.5. Statistical analysis

Data in the study were input in SPSS20.0 software, measurement data was in terms of ($\bar{x}\pm s$), comparison between groups was by t test, correlation analysis was by Pearson test and P<0.05 indicated statistical significance in differences.

3. Results

3.1. Carotid ultrasound parameters

Carotid ultrasound parameters β, Ep, AC and PWVβ value of observation group were higher than those of control group, and differences were statistically significant (P<0.05). Carotid ultrasound parameters β, Ep, AC and PWVβ value of double-vessel disease group were higher than those of single-vessel disease group, carotid ultrasound parameters β, Ep, AC and PWVβ value of triple-vessel disease group were higher than those of single-vessel disease group and double-vessel disease group, and differences were statistically significant (P<0.05), shown in Table 1.

3.2. Cardiac function parameters

Cardiac function parameters LVEDD and LVESD value of observation group were higher than those of control group while LVEF value was lower than that of control group, and differences were statistically significant (P<0.05). Cardiac function parameters LVEDD and LVESD value of double-vessel disease group were higher than those of single-vessel disease group while LVEF value was lower than that of single-vessel disease group; cardiac function parameters LVEDD and LVESD value of triple-vessel disease group were higher than those of single-vessel disease group and double-

Table 1

Comparison of carotid ultrasound parameter value ($\bar{x}\pm s$).

Groups	n	β	Ep	AC (mm^2/kPa)	PWVβ (m/s)
Single-vessel disease group	50	5.71±0.59[a]	118.46±13.58[a]	0.69±0.07[a]	5.78±0.65[a]
Double-vessel disease group	72	7.62±0.73[ab]	142.51±15.88[ab]	0.82±0.09[ab]	8.12±0.96[ab]
Triple-vessel disease group	58	9.27±0.98[abc]	173.28±19.74[abc]	0.97±0.09[abc]	10.74±1.95[abc]
Control group	50	5.21±0.57	104.26±11.78	0.58±0.06	4.09±0.43

vs. control group, [a]P<0.05; vs. single-vessel disease group, [b]P<0.05; vs. double-vessel disease group, [c]P<0.05.

vessel disease group while LVEF value was lower than that of single-vessel disease group and double-vessel disease group, and differences were statistically significant (P<0.05), shown in Table 2.

Table 2

Comparison of cardiac function parameter value ($\bar{x}\pm s$).

Groups	n	LVEDD (mm)	LVESD (mm)	LVEF (%)
Single-vessel disease group	50	61.16±6.95[a]	48.51±5.79[a]	57.55±6.02[a]
Double-vessel disease group	72	64.09±7.84[ab]	52.05±5.88[ab]	52.17±5.98[ab]
Triple-vessel disease group	58	69.82±8.19[abc]	59.63±6.7[abc]	46.85±5.72[abc]
Control group	50	58.25±6.81	42.73±5.86	61.27±6.93

vs. control group, [a]P<0.05; vs. single-vessel disease group, [b]P<0.05; vs. double-vessel disease group, [c]P<0.05.

3.3. Endothelial function index

Endothelial function indexes ET-1 and vWF levels of observation group were higher than those of control group while NO level was lower than that of control group, and differences were statistically significant (P<0.05). Endothelial function indexes ET-1 and vWF levels of double-vessel disease group were higher than those of single-vessel disease group while NO level was lower than that of single-vessel disease group; endothelial function indexes ET-1 and vWF levels of triple-vessel disease group were higher than those of single-vessel disease group and double-vessel disease group while NO level was lower than that of single-vessel disease group and double-vessel disease group, and differences were statistically significant (P<0.05), shown in Table 3.

Table 3

Comparison of endothelial function index levels ($\bar{x}\pm s$).

Groups	n	ET-1 (ng/L)	NO (μmol/L)	vWF (%)
Single-vessel disease group	50	48.64±5.83[a]	85.73±8.05[a]	93.21±9.87[a]
Double-vessel disease group	72	73.21±7.85[ab]	68.34±7.18[ab]	126.94±15.73[ab]
Triple-vessel disease group	58	115.23±17.94[abc]	42.62±5.09[abc]	193.52±23.74[abc]
Control group	50	32.18±3.95	93.75±9.68	70.16±7.85

vs. control group, [a]P<0.05; vs. single-vessel disease group, [b]P<0.05; vs. double-vessel disease group, [c]P<0.05.

3.4. Correlation analysis

Through Pearson test analysis, the correlation between carotid ultrasound parameters and cardiac function parameters in patients with coronary heart disease was as follows: carotid ultrasound parameters β, Ep, AC and PWVβ value were positively correlated with LVEDD and LVESD value, and negatively correlated with LVEF value (P<0.05); the correlation with endothelial function was as follows: carotid ultrasound parameters β, Ep, AC and PWVβ value were positively correlated with ET-1 and vWF levels, and negatively correlated with NO level (P<0.05).

4. Discussion

Among the clinically diagnosed patients with coronary heart disease, the vast majority is associated with different degrees of carotid atherosclerosis, and many scholars have also confirmed that under the common pathological basis such as hyperlipidemia, endothelial injury and oxidative stress, coronary-like lesions can appear in carotid artery[5]. In the study, 180 patients with coronary heart disease and 50 healthy control subjects in our hospital all received carotid ultrasonography, and it was found that compared with the control group, patients with coronary heart disease were with higher ultrasound parameters β, Ep, AC and PWVβ value, and with the increase in the number of coronary lesions, the degree of the above changes increased. It indicates that there are carotid atherosclerotic lesions in patients with coronary heart disease, and with the increase in the number of coronary lesions, the carotid atherosclerosis increases. The study of Zhang *et al* shows that carotid artery is the most easily involved in atherosclerosis, carotid artery location is shallow, the ultrasound can obtain high-quality image of it, and it is the window of the systemic atherosclerosis lesions[6]. Further research is needed to clarity whether the carotid ultrasonography can be used as the objective standard for coronary heart disease screening and severity classification.

Cardiac function is directly related to the severity of coronary heart disease, and with the increase of coronary artery lesion severity and myocardial ischemia, patients′ cardiac function will be worsening[7,8]. The study of Liang *et al* has confirmed that the LVEDD and LVESD increase while LVEF decreases in patients with coronary artery disease[9]. The study of Li *et al* also shows that LVEF level can reflect the changes in patients′ cardiac function in real time, and is one of the most reliable indicators for monitoring of coronary heart disease[10]. It was found in the study that compared with healthy control group, patients with coronary heart disease are with the changes in the value of common color Doppler ultrasound cardiac function parameters such as LVEDD, LVESD and LVEF; and with the aggravation of coronary artery lesions, LVEDD and LVESD value continued to increase while LVEF value continued to decrease. The above results show that there is cardiac dysfunction in patients with coronary heart diseases, the cardiac function further deteriorates with the increase in the severity of coronary artery lesions, and this is basically consistent with the research results of Guo *et al*[11], and whereas also define the reliability and authority of cardiac function parameters as the indexes to judge coronary heart disease condition.

The study of He *et al* shows that endothelial dysfunction plays "the center" role in the development of cardiovascular disease, and early detection of endothelial function has an important predictive value for cardiovascular adverse events[12]. The study of Zhou *et al* shows that endothelial function damage is throughout the entire process of coronary heart disease, and endothelial function index detection can be the auxiliary means to judge the disease condition[13]. ET-1 and NO are derived from vascular endothelial cells, EF-1 can promote vascular smooth muscle cell proliferation and induce coronary spasm, and NO belongs to vascular cytoprotection factor, exerts vasodilatory effect and can inhibit the coronary inflammatory cell adhesion and free radical damage[14,15]. vWF is a macromolecule glycoprotein synthesized by vascular endothelium, a large number of vWF are released after vascular endothelial injury, and therefore, high level of vWF is the visual symbol of vascular dysfunction[16–18]. The

study results showed that compared with control group, patients with coronary heart disease are with higher serum ET-1 and vWF levels, and lower NO level, indicating that there is vascular endothelial dysfunction in patients with coronary heart disease; with the number of coronary artery lesions increases in patients with coronary heart disease, serum ET-1 and vWF levels further increase while NO level further decreases, showing that endothelial index levels can intuitively reflect the severity of coronary artery disease.

The inner link of ultrasonic cardiac function parameters and endothelial function indexes with the severity of coronary heart disease has been recognized, and the directivity of the degree of carotid artery atherosclerosis to coronary heart disease is still not clear[19,20]. It has been made clear in the study that there is significant carotid atherosclerosis in patients with coronary heart disease, and in order to define the inner link between the ultrasound parameters of carotid atherosclerosis and the severity of coronary heart disease, Pearson was further used in the study to analyze the relationship between the two, and it was found that carotid ultrasound parameters β, Ep, AC and PWVβ value were positively correlated with LVEDD and LVESD value, and negatively correlated with LVEF value (P<0.05); the correlation with endothelial function was as follows: carotid ultrasound parameters β, Ep, AC and PWVβ value were positively correlated with ET-1 and vWF levels, and negatively correlated with NO level (P<0.05). It shows that the ultrasound parameters of carotid atherosclerosis are directly correlated with the severity of coronary heart disease.

To sum up, it is concluded as follows: the ultrasound parameter levels of carotid atherosclerosis in patients with coronary heart disease are directly correlated with the disease severity, can be used as the noninvasive and reliable means for early judgment of the disease, and are worth popularization and application in clinical practice in the future.

References

[1] Li K, Yang X, Wang L, et al. Modification of the association between smoking status and severity of coronary stenosis by vitamin D in patients suspected of coronary heart disease. *Medicine (Baltimore)* 2016; **95**(36): e4817.

[2] Um T, Lee DH, Kang JW, et al. The degree of diabetic retinopathy in patients with type 2 diabetes correlates with the presenceand severity of coronary heart disease. *J Korean Med Sci* 2016; **31**(8): 1292-1299.

[3] He Y, Li XJ, Peng HY, et al. Contrast-enhanced ultrasound time-intensity curve evaluates the correlation between carotid atherosclerotic plaque stability and type 2 diabetes mellitus complicated with coronary heart disease. *J Pract Med* 2016; **32**(4): 600-603.

[4] Jian PH, Xu LF, Zhang TJ. Ultrasound evaluation of carotid atherosclerosis and its predicting value for coronary heart disease. *J Hainan Med Univ* 2016; **22**(12): 1217-1220.

[5] Zhang H, Liu M, Ren T, et al. Associations between carotid artery plaque score, carotid hemodynamics and coronary heart disease. *Int J Environ Res Public Health* 2015; **12**(11): 14275-14284.

[6] Zhang H, Yu SJ, Mao YJ, et al. Detection of the degree of carotid artery atherosclerosis in high Lp (a) family members by carotid intima-media thickness measurement and ultrasonic echo tracking technique. *Chin General Pract* 2015; **18**(30): 3759-3762.

[7] Wang W, Jiang Y, Lee CH. Independent predictors of physical health in community-dwelling patients with coronary heart disease in Singapore. *Health Qual Life Outcomes* 2016; **14**(1): 113.

[8] Ganz P, Heidecker B, Hveem K, et al. Development and validation of a protein-based risk score for cardiovascular outcomes among patients with stable coronary heart disease. *JAMA* 2016; **315**(23): 2532-2541.

[9] Liang B, Qi Z, Ding HY, et al. Correlation study between B-type natriuretic peptide and the degree of coronary artery disease as well as cardiac function. *Chin J Pract Internal Med* 2015; **35**(3): 257-260.

[10] Li Q, Guo ZB, Li QM, et al. Effects of Qili Qiangxin capsule on serum concentration of adiponectin and heart function in patients with coronary heart disease combined with congestive heart failure. *Chin J Pathophysiol* 2014; **30**(6): 1119-1122.

[11] Guo H, Chen J, Suo DW. Impact of rosuvastatin on cardiac function, lipid levels, blood rheology level and endothelial function in patients with coronary artery disease. *Chin J Biochem Pharm* 2015; **35**(5): 98-101.

[12] He SS, Wang Y, Guo LS, et al. Endothelial function was correlated with the plasma level of homocysteine and carotid intima-media thickness in patients with unstable angina pectoris. *Chin J Arteriosclerosis* 2016; **24**(7): 705-708.

[13] Zhou JR, Wang AL, Yang LF, et al. The influence of nicorandil on vascular endothelial function and serum hypersensitive C-reactive protein level in patients with chronic stable coronary heart disease after percutaneous coronary intervention. *Chin J Gerontol* 2016; **36**(5): 1107-1110.

[14] Chumachenko PV, Ivanova AG, Belokon EV, et al. Adhesion molecules and mononuclear cell subpopulations in the coronary and pulmonary arteries of patients with coronary heart disease. *Arkh Patol* 2015; **77**(6): 9-14.

[15] Liang Y, Li YP, He F, et al. Long-term, regular remote ischemic preconditioning improves endothelial function in patients with coronary heart disease. *Braz J Med Biol Res* 2015; **48**(6): 568-576.

[16] Yang J, Zhang XW, Deng YP, et al. Effect of Shexiang Tongxin Dropping Pill on improving vascular endothelial function in patients with coronary heart disease. *Chin Arch Trad Chin Med* 2016; **34**(9): 2188-2191.

[17] Zhang M, Wang W. Study on the correlation of serum leptin and resistin with endothelial function in H-type hypertension. *J Clin Cardiol* 2016; **32**(1): 90-93.

[18] Yang QH, Shen W, Jia XD, et al. Correlation of ultrasound detection of carotid atherosclerosis plaque with ischemic cerebral stroke. *J Hainan Med Univ* 2016; **22**(15): 1755-1757.

[19] Vijayakumar M, Vasudevan DM, Sundaram KR, et al. A randomized study of coconut oil versus sunflower oil on cardiovascular risk factors in patients with stable coronary heart disease. *Indian Heart J* 2016; **68**(4): 498-506.

[20] Slimani A, Harira Y, Trabelsi I, et al. Effect of E670G polymorphism in PCSK9 gene on the risk and severity of coronary heart disease and ischemic stroke in a Tunisian cohort. *J Mol Neurosci* 2014; **53**(2): 150-157.