Significance of Carotid Ultrasound Parameters and Ambulatory Arterial Stiffness Index in Coronary Heart Disease Risk Prediction: Postprint

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Abstract

Objective To investigate the relationship between carotid ultrasound-related indicators, dynamic arteriosclerosis index, and coronary heart disease.

Methods Dynamic arteriosclerosis index, carotid ultrasound, and coronary angiography were examined in 110 patients with coronary heart disease. Based on coronary angiography results, patients were divided into single-vessel disease group (n=40), double-vessel disease group (n=37), and triple-vessel or more disease group (n=33). Simultaneously, according to carotid ultrasound examination, patients were divided into mild carotid stenosis group (n=42), moderate stenosis group (n=46), and severe stenosis group (n=22). Fifty healthy individuals undergoing physical examination during the same period were selected as the normal control group. Blood pressure, dynamic arteriosclerosis index, carotid intima-media thickness, carotid atherosclerotic plaque score, and coronary artery score were compared among the four groups, and correlation analysis was performed.

Results There were no statistically significant differences in systolic and diastolic blood pressure among patients with different numbers of coronary lesions and different degrees of carotid stenosis ($P>0.05$). Regarding dynamic arteriosclerosis index: triple-vessel disease group > double-vessel disease group > single-vessel disease group > control group ($P<0.05$); severe carotid stenosis group > moderate stenosis group > mild stenosis group > control group ($P<0.05$). Carotid intima-media thickness in coronary heart disease patients was significantly higher than that in the control group ($P<0.05$), but there was no statistically significant difference in carotid intima-media thickness among the coronary heart disease groups ($P>0.05$). Comparison of plaque score and coronary score among groups: triple-vessel disease group > double-vessel disease group > single-vessel disease group > control group ($P<0.05$); severe stenosis group > moderate stenosis group > mild stenosis group > control group (P<0.05). Dynamic arteriosclerosis index was positively correlated with the number of coronary lesions and degree of carotid stenosis (r=0.72, 0.65, P<0.05). Plaque score and coronary score were both positively correlated with the number of coronary lesions and degree of carotid stenosis (r=0.88, 0.19, 0.42, 0.31, P<0.05).

Conclusion Carotid ultrasound-related indicators and dynamic arteriosclerosis index can objectively reflect the degree of arteriosclerosis and atherosclerotic plaque lesions in patients, enabling early prediction and assessment of coronary heart disease risk, and providing an objective and reliable basis for early clinical intervention.

Full Text

Carotid Ultrasound-Related Indicators and Dynamic Arterial Stiffness Index in Coronary Heart Disease Risk Prediction

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Abstract

Objective To investigate the relationship between carotid ultrasound-related parameters, dynamic arterial stiffness index (AASI), and coronary heart disease (CHD).

Methods AASI, carotid ultrasound, and coronary angiography were performed in 110 CHD patients. Based on coronary angiography findings, patients were divided into single-vessel disease group (n=40), double-vessel disease group (n=37), and triple-vessel or more disease group (n=33). According to carotid ultrasound examination, patients were categorized into mild carotid stenosis group (n=42), moderate stenosis group (n=46), and severe stenosis group (n=22). Fifty healthy individuals undergoing physical examination during the same period were selected as normal controls. Blood pressure, AASI, carotid intima-media thickness (IMT), carotid atherosclerotic plaque score, and coronary artery score were compared among the four groups, and correlation analysis was performed.

Results There were no significant differences in systolic and diastolic blood pressure among patients with different numbers of coronary lesions or different degrees of carotid stenosis (P>0.05). AASI comparisons showed: triple-vessel disease group > double-vessel disease group > single-vessel disease group >

control group (P<0.05), and severe carotid stenosis group > moderate stenosis group > mild stenosis group > control group (P<0.05). IMT in CHD patients was significantly higher than in the control group (P<0.05), but there was no significant difference in IMT among CHD groups (P>0.05). Plaque scores and coronary scores across groups showed: triple-vessel disease group > double-vessel disease group > single-vessel disease group > control group (P<0.05), and severe stenosis group > moderate stenosis group > mild stenosis group > control group (P<0.05). AASI was positively correlated with both the number of coronary lesions and carotid stenosis degree (r=0.72, 0.65, P<0.05). Plaque scores and coronary scores were positively correlated with both the number of coronary lesions and carotid stenosis degree (r=0.88, 0.19, 0.42, 0.31, P<0.05).

Conclusion Carotid ultrasound-related parameters and dynamic arterial stiffness index can objectively reflect the degree of arterial stiffness and atherosclerotic plaque pathology, enabling early prediction and assessment of CHD risk and providing an objective and reliable basis for early clinical intervention.

Keywords: carotid ultrasound; dynamic arterial stiffness index; coronary heart disease

Introduction

Changes in arterial wall structure and function are closely associated with the incidence and mortality of cardiovascular disease, and the degree of peripheral atherosclerotic lesions can reflect and predict coronary atherosclerotic disease and its severity. The carotid and coronary arteries share similar embryological development, pathophysiological characteristics, and anatomical structures, with common pathogenic mechanisms in atherosclerosis, making the carotid artery a window for reflecting systemic atherosclerotic lesions. Increased carotid intima-media thickness (IMT) is an independent risk factor for cardiovascular and cerebrovascular diseases, positively correlated with increased CHD risk. Arterial stiffness increases with age due to changes in vascular wall composition and shear stress, which exacerbates vascular hardening. Functional changes in the vascular wall can increase arterial stiffness and lead to poor cardiovascular prognosis.

Yang et al. used color Doppler ultrasound to measure carotid IMT and plaque burden in CHD patients, demonstrating a correlation between carotid atherosclerosis severity and coronary artery stenosis. Wang et al. proposed the dynamic arterial stiffness index (AASI) based on the principle that pulse pressure increases with arterial stiffness, utilizing conventional 24-hour ambulatory blood pressure monitoring data to reflect the dynamic relationship between systolic and diastolic pressure, thereby more accurately indicating arterial stiffness. To enable multi-parameter prediction and assessment of CHD, this study integrated these research findings to comprehensively analyze AASI, IMT, carotid plaque characteristics, and coronary angiography findings, investigating the relationship between dynamic arterial stiffness index, carotid ultrasound parameters, and coronary heart disease.

1.1 General Data

We selected 110 CHD patients admitted to our hospital from January 2012 to February 2014, including 56 males and 54 females aged 39-77 years (mean 61.2±16.9 years). All patients had cardiac function NYHA class I-III. Patients were excluded if they had valvular heart disease, congenital heart disease, cardiomyopathy, secondary hypertension, hepatic or renal insufficiency, malignancy, extreme wasting disease, cachexia, rheumatoid arthritis, systemic lupus erythematosus, arteritis, or other conditions affecting carotid IMT or atherosclerosis assessment. Inclusion criteria were diagnosis of hypertension according to the 2005 Chinese Hypertension Prevention and Treatment Guidelines (systolic pressure >140 mmHg and/or diastolic pressure >90 mmHg without antihypertensive medication) and diagnosis of CHD based on electrocardiography, cardiac enzymes, and coronary angiography.

1.2 Grouping Method

Based on coronary angiography results, patients were divided into single-vessel disease group (n=40), double-vessel disease group (n=37), and triple-vessel or more disease group (n=33). According to carotid ultrasound examination, patients were categorized into mild carotid stenosis group (n=42), moderate stenosis group (n=46), and severe stenosis group (n=22). Fifty healthy individuals undergoing physical examination during the same period served as normal controls.

1.3 Examination Methods

1.3.1 Carotid Ultrasound Examination Using a Philips IE33 color Doppler ultrasound diagnostic system with a 7.5-10 MHz high-frequency linear array transducer, examinations were performed within one week after coronary angiography by the same physician. Patients were examined in supine position with the neck fully exposed and head turned to the contralateral side. Both common carotid arteries, carotid bifurcations, internal carotid artery origins, and external carotid arteries were examined longitudinally and transversely along the course of the carotid artery between the sternocleidomastoid muscle and trachea. IMT <1.0 mm was considered normal, while >1.2 mm indicated atherosclerotic plaque formation. Plaque location, size, morphology, and echo characteristics were observed, along with color flow signals, defects, and spectral patterns to estimate the degree of luminal narrowing. Diameter reduction <50% was considered mild stenosis, 51%-70% moderate, 71%-99% severe, and 100% occlusion. The Crouse method was used to calculate plaque score by summing the maximum thickness of all carotid plaques without considering plaque length.

1.3.2 AASI Measurement Using a Space Labs 90207 non-invasive ambulatory blood pressure monitor, left upper arm arterial pressure was measured over 24 hours, with automatic measurements every 20 minutes during daytime (6:00-22:00) and every 30 minutes at night (22:00-6:00). AASI was calculated from ambulatory blood pressure data by plotting systolic pressure on the x-axis and diastolic pressure on the y-axis to create a scatter plot of individual 24-hour blood pressure readings. The regression slope of diastolic on systolic pressure was calculated, and AASI was derived as 1 minus this regression slope, with values closer to 1 indicating lower arterial compliance.

1.3.3 Coronary Artery Lesion Assessment Coronary angiography was performed to evaluate the degree of luminal narrowing in the left main, circumflex, anterior descending, and right coronary arteries. CHD was diagnosed when at least one vessel had >50% diameter stenosis. The Gensini scoring system was used to assess coronary lesion severity: <25% stenosis = 1 point, 25%-49% = 2 points, 50%-74% = 4 points, 75%-89% = 8 points, 90%-99% = 16 points, and 100% occlusion = 32 points.

1.3.4 Observation Indicators Blood pressure, AASI, IMT, carotid atherosclerotic plaque score, and coronary score were compared among groups with different numbers of coronary lesions and different degrees of coronary stenosis. Correlations between these indicators and coronary lesion number/stenosis degree were analyzed.

1.4 Statistical Analysis

SPSS 17.0 software was used for statistical analysis. Measurement data were expressed as mean ± standard deviation. Comparisons between two groups used t-tests, multi-group comparisons used ANOVA, rate comparisons used ^{2} analysis, and correlation analysis used linear correlation. P<0.05 was considered statistically significant.

Results

2.1.1 Blood Pressure, AASI, and IMT in Patients with Different Numbers of Coronary Lesions

There were no significant differences in systolic or diastolic blood pressure among groups (P>0.05). AASI showed progressive increases: triple-vessel disease group > double-vessel disease group > single-vessel disease group > control group (P<0.05). Compared with controls, IMT was significantly increased in all CHD groups (P<0.05), but there was no significant difference in IMT among the CHD groups themselves (P>0.05,). Correlation analysis revealed that AASI was significantly positively correlated with the number of coronary lesions (r=0.392, P=0.014).

2.1.2 Carotid Atherosclerotic Plaque Score and Coronary Score

Plaque scores and coronary scores differed significantly among the triple-vessel, double-vessel, single-vessel disease groups, and control group ($P<0.05$,). Correlation analysis showed that both plaque score and coronary score were positively correlated with the number of coronary lesions ($r=0.637$, $P=0.0001$; $r=0.398$, $P=0.044$).

2.2.1 Blood Pressure, AASI, and IMT in Patients with Different Degrees of Carotid Stenosis

There were no significant differences in blood pressure among groups with different degrees of carotid stenosis ($P>0.05$). ANOVA with pairwise comparisons revealed significant differences in AASI among groups ($P<0.05$), with severe stenosis group > moderate stenosis group > mild stenosis group > control group. IMT in CHD patients with mild, moderate, and severe carotid stenosis was significantly higher than in controls ($P<0.05$), but there was no significant difference among the three CHD groups ($P>0.05$,). AASI was positively correlated with carotid plaque score ($r=0.481$, $P=0.015$).

2.2.2 Carotid Plaque Score and Coronary Score in Patients with Different Degrees of Carotid Stenosis

ANOVA with pairwise comparisons showed that plaque scores and coronary scores were highest in the severe stenosis group, followed by moderate, mild, and control groups ($P<0.05$,). Correlation analysis demonstrated that both plaque score and coronary score were positively correlated with carotid stenosis degree ($r=0.568$, $P=0.0001$; $r=0.501$, $P=0.0001$).

Discussion

Atherosclerosis progression from early stage to clinical manifestation can be divided into three phases: vascular endothelial dysfunction, intimal thickening, and atherosclerotic plaque formation, which can occur simultaneously in multiple tissues including lower extremity arteries, renal arteries, carotid arteries, and cerebral arteries. Studies have shown that patients with carotid atherosclerosis have more than three times the risk of acute myocardial infarction compared to those without, and each 0.1 mm increase in IMT corresponds to an 11% increase in cardiovascular disease risk. Increased IMT represents an early characteristic manifestation of atherosclerosis, while plaque formation is a significant feature reflecting disease progression. Coronary angiography accurately assesses coronary atherosclerotic lesions but is invasive and difficult to popularize. Therefore, exploring a non-invasive, simple method for early CHD risk assessment is crucial.

During ultrasound examination, the intima and media layers are difficult to separate, so this study examined them together. IMT thickening is a pre-plaque manifestation and pathological basis that can progress to atherosclerotic plaques composed of organized thrombus, intraplaque hemorrhage, lipid deposition, fibrosis, or calcification. Our study found that increased IMT was associated with more coronary lesions and higher coronary stenosis degree, consistent with Wang' s research. IMT thickening is an early indicator of atherosclerosis, while plaque formation reflects disease severity. Some scholars consider carotid ultrasound valuable in assessing CHD severity, suggesting IMT can serve as a window for systemic atherosclerosis and an indicator for evaluating CHD risk and disease progression.

Early-stage arterial stiffness manifests as reduced arterial compliance and increased rigidity, with the relationship between systolic and diastolic pressure reflecting vascular elastic function. AASI represents the regression slope between 24-hour ambulatory diastolic and systolic pressures. Twenty-four-hour ambulatory blood pressure monitoring provides abundant data for precise analysis and early prediction of atherosclerotic plaque formation risk. More severe arterial stiffness yields AASI values closer to 1. Our study demonstrated that increased AASI was associated with more coronary lesions and higher carotid stenosis degree, with significant positive correlations. These results confirm that AASI can serve as an independent CHD warning indicator that better reflects vascular stiffness. We also found that increased carotid plaque score and coronary score were significantly positively correlated with both coronary lesion number and carotid stenosis degree. Carotid plaque score is obtained through carotid ultrasound, and similar studies have reported good correlation between carotid plaque score and coronary Gensini score. Thus, AASI and carotid plaque score can predict coronary artery disease risk and progression.

In conclusion, carotid ultrasound IMT measurement, plaque score calculation, and dynamic arterial stiffness index monitoring can objectively reflect arterial stiffness and atherosclerotic plaque severity, enabling early CHD risk prediction and assessment to provide an objective, reliable basis for early clinical intervention.

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Note: Figure translations are in progress. See original paper for figures.