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The assessment of the cardiac compensatory function of elderly people with coronary artery disease by quantitive dobutamine stress echocardiography

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Abstract. – OBJECTIVE: The aim of the study is to investigate the cardiac compensatory function change in senior people with Coronary Artery Disease (CAD) by Quantitive Dobutamine Stress Echocardiography (DSE) and Tissue Doppler Imaging (TDI).

PATIENTS AND METHODS: All of the 98 senior people (age >60) who were suspected to have CAD received the examination of DSE and TDI. The mean systolic peak velocity (Sa), early diastolic peak velocity (Ea) and late diastolic peak velocity (Aa) of mitral annulus were measured in a different dose of dobutamine stress. Besides, the coronary angiography (CAG) was done within 2 weeks for the 98 senior people.

RESULTS: In the basic status, the mean Sa, Ea and Aa were not significantly different between the patients from the normal group and CAD group. However, under a 20 μg/kg·min dose of dobutamine stress, significant differences of mean Sa and Ea between two groups were observed. For the mean Aa, a significant difference could be observed with the dose of 40 μg/kg·min.

CONCLUSIONS: Both the cardiac systolic and diastolic compensatory function were lower in the CAD group than the normal group, which is detectable in the 20 μg/kg·min dose of dobutamine stress status. In other words, Quantitive Dobutamine Stress Echocardiography is a safe, efficient, non-invasive diagnostic method. It can reflect the compensatory cardiac function of the patients with CAD.

Key Words:
Dobutamine, Cardiac function, Coronary artery disease.

Introduction

Coronary artery disease (CAD) keeps with high morbidity and mortality throughout the world[1]. It is the second leading cause of cardiovascular death in the China, accounting for 22% of cardiovascular deaths in urban areas and 13% in rural region[2]. CAD could be asymptomatic in the early stage[3]. In its process, the cardiac function of the patients gradually decreases. At present, the main method to estimate the cardiac function is echocardiography, which can detect the change of the systolic and diastolic function[4,5]. If the decrease of the cardiac function could be observed earlier, it would be helpful for preventing the development of CAD.

Dobutamine Stress Echocardiography (DSE) is a technique to detect the compensatory cardiac function through the dobutamine that can increase the oxygen consumption of the myocardium, leading to the myocardial ischemia and cardiac dysfunction. It is a qualitative approach for CAD diagnosis, with relatively high probability resulting in misdiagnosis and missed diagnosis[6,7]. Tissue Doppler Imaging (TDI) is a new ultrasonic technique, which can assess the cardiac function quantitatively. TDI can markedly improve the diagnostic accuracy by analyzing myocardial function[8,9]. Both DSE and TDI have been utilized extensively in the detection of CAD[10-13].

Heart failure might not be clinically evident in early-stage CAD patients due to the decompensation of cardiac function. Thus, the timely detection and diagnosis are vital for interventions conducted in the decompensation of CAD patients. In the previous studies for CAD diagnosis, the cardiac systolic function was assessed only[14,15], while few studies focused on the diastolic function. When the diagnosis has been made with DSE, clinicians mainly observe the wall motion by naked eyes. This may introduce the subjective bias into diagnosis. Moreover, the decrease of diastolic function usually precedes that of systolic in cardiac function descent of CAD patient. Thus, the assessment of diastolic function can contribute to the early observation of cardiac

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function change, and the subsequent intervention to CAD patients.

In the present study, we used the mitral annular systolic and diastolic motion velocities to indicate the patients' systolic and diastolic functions, respectively. By this, the conventional qualitative approach evolves to be quantitative, which helps improve the diagnosis accuracy. The cardiac function of CAD patients can be reflected comprehensively with the quantitative method, and the change of cardiac compensation can be observed earlier and more accurately.

Patients and Methods

Patients

The inpatients who were suspected with CAD and older than 60 years old in our Department of Cardiology were recruited. Totally 98 cases (51 males, 47 females), mean age of 66±5 years old (60-81 years old), were involved.

Exclusion criteria: (1) Patients who had ventricular wall motion abnormalities under the conventional echocardiography, or valvular heart disease, cardiomyopathy, congenital heart disease, heart failure, pulmonary heart disease, hyperthyroidism, stroke, renal insufficiency, malignant arrhythmia. (2) All of the patients had the DSE, then received the CAG within 2 weeks.

The study was approved by the Ethics Committee of Beijing Hospital of the Ministry of Health. Informed consents have been signed by all the patients involved in this study.

Instrument and Methods

We used GE Vivid 7 color Doppler ultrasonic machine (General Electric Company, Easton Turnpike, Fairfield, CT, USA), with the transducer frequency of 3.5 MHz, investigation depth of 15-17 mm, scanning angle of 90°-120°. On the condition of frame frequency 100 Hz, when acquired the images, started the TDI.

DSE examination: Stopped the drugs, for example nitric acid ester, β-Recptor blocker, calcium antagonists and so on for at least 24 hours before the dobutamine (Dob) stress test. The initial concentration of the Dob was 5 μg/(kg·min), increased the dose each 3 minutes according to the order of 5, 10, 20, 30, 40 μg/(kg·min). When necessary, the atropine was added (a total dose lower than 1 mg), in order to get the target heart rate. The computational formula was (220-age)×0.85. Meanwhile, we continued electrocardiogram (ECG) monitoring, recorded the heart rate, rhythm of the heart, blood pressure and symptom of the patients at each 3rd minute after the adding of Dob and finished the image acquisition at the same time.

Image Acquisition and Analysis

Firstly, under the mode of conventional ultrasound and TDI, the standard images of the parasternal long axis, apical four-chamber and apical two-chamber view at 6 stages were acquired and stored, which included basic status, 10, 20, 30, 40 μg/(kg·min) dose status and recover phase. Then, we quantitatively analyzed the images using the software of EchoPac 8.0. The mean systolic peak velocity (Sa), early diastolic peak velocity (Ea) and late diastolic peak velocity (Aa) of mitral annulus were measured in a different dose of dobutamine stress.

The measured position of mitral annulus included the lateral wall, posterior interseptum, anterior wall, inferior wall, posterior wall, anterior interseptum. The terminal velocity was the mean velocity of the 6 positions in 3 cardiac cycles. The size of sample frame was set to 5 mm×10 mm (width×height).

Statistical Analysis

The database was established using SPSS 13.0 (SPSS Inc., Chicago, IL, USA). Continuous variables were expressed as mean±SD. The comparisons of the Sa, Aa and Ea of the mitral annulus between normal group and CAD group were performed using the Student *t*-test. Categorical variables were expressed as percentages and chi-square test was used. A significance level of 0.05 was used for hypothesis testing.

Results

Demographic Information

There were no statistical differences in age, sex, basic heart rate, blood pressure as well as the cardiac structure and function in a normal group and CAD group ($p>0.05$). (Table I).

The Results of the CAG

The patients were divided into CAD group (55 cases) and normal group (43 cases) according to the results of CAG. In the CAD group, the lesions of the anterior descending branch, left circumflex branch and right coronary artery were 45, 23, 25, respectively.

Table I. Patients' demographics (Mean±SD).

	Normal group	CAD group	*p*-value
Males/Females (cases)	29/26	22/21	1.0
Age (year)	66.8±5.0	65.8±5.7	0.3693
HR (beat/min)	70.2±12.8	66.6±8.5	0.1043
Systolic BP (mmHg)	135.3±18.2	132.1±17.8	0.4242
Diastolic BP (mmHg)	77.1±9.1	76.0±9.3	0.5952
The D of LV (mm)	46.5±4.8	47.9±5.8	
The D of LA (mm)	36.1±3.4	35.9±4.1	
IVS (mm)	8.1±1.8	8.6±1.7	
Posterior wall of LV (mm)	8.3±1.7	8.4±1.9	
LVEF (%)	87.3±2.1	81.7±8.3	0.0274

HR: Heart rate, BP: blood pressure, D: diameter, LV: left ventricle, LA: left atrium, IVS: interventricular septum, LVEF: left ventricular ejection fraction.

Conventional Dobutamine Stress Echocardiography

There were no statistical differences about Left Ventricular Ejective Fraction (LVEF) between normal and CAD group ($p>0.05$). (Table II)

Quantitatively Dobutamine Stress Echocardiography

Normal group: Both the systolic peak velocity and diastolic peak velocity were increased gradually along with the addition of dobutamine stress dose. The maximum was gotten at 40 μg/(kg·min).

CAD group: The mean Sa and Ea of the mitral annulus in CAD group were less than the normal group from the dobutamine dose of 20 μg/(kg·min) ($p<0.05$). The Aa didn't have statistical differences even though the dose of the dobutamine had reached to 40 μg/(kg·min) ($p>0.05$). (Table III, IV, V)

Discussion

The assessment of the cardiac function for the CAD patients is very important for the prognosis, especially in the judgment of the compensatory cardiac function. Conventional echocardiography can only detect the decrease of the cardiac function about the late phase of the CAD patients. Due to the compensatory cardiac status about the early phase of the CAD patients, the change of the cardiac function cannot be detected timely.

Dobutamine Stress Echocardiography (DSE) is a very important method in the area of the cardiovascular ultrasound diagnosis. This technique can detect the ischemic myocardium through the addition of dobutamine, which can increase the oxygen consumption of the myocardium and induce the myocardial ischemia[16,17].

TDI is a new promising developed ultrasound technique in recent years, which can evaluate the regional cardiac function quantitatively[18]. The measurement of the average velocity at mitral annulus can not only reflect the ventricular systolic function but also the diastolic function[19,20]. This one provides the basis for the evaluation of the systolic and diastolic function in the CAD patients.

In this study, we analyzed the movement status of the mitral annulus in different loading dose by the combining DSE and TDI, then estimated the compensatory cardiac function of the patients. When the dose of Dob was greater than 20 μg/kg·min, the mean Sa and Ea of the mitral annulus in CAD group were lower than the normal

Table II. The comparison of LVEF between the normal and CAD group (Mean±SD).

Groups (# of cases)	Rest status	10 μg/kg.min	20 μg/kg.min	30 μg/kg.min	40 μg/kg.min
Normal (47)	68.3±7.8	70.1±8.9	73.4±9.5	75.3±10.3	79.8±8.3
CAD (51)	65.9±8.5	69.4±10.4	72.8±9.1	74.1±9.5	78.1±10.1

Comparision with normal group, $^{*}p<0.05$.

Table III. The comparison of Sa between the normal and CAD group (Mean±SD).

Groups (# of cases)	Rest status	10 μg/kg.min	20 μg/kg.min	30 μg/kg.min	40 μg/kg.min
Normal (47)	9.6±1.4	12.1 ±1.7	13.3±2.1	14.2±2.0	14.9±1.9
CAD (51)	9.7±1.9	11.8 ±1.9	12.4±1.8*	12.9±1.9*	13.1±1.8*

Comparison with normal group, $^{*}p<0.05$

Table IV. The comparison of Ea between the normal and CAD group (Mean±SD).

Groups (# of cases)	Rest status	10 μg/kg.min	20 μg/kg.min	30 μg/kg.min	40 μg/kg.min
Normal (47)	14.2±2.5	15.6 ±1.7	16.9±2.2	17.6±2.6	17.9±2.9
CAD (51)	14.4±2.9	15.1±2.1	15.3±1.9*	15.8±1.9*	15.9±2.4*

Comparison with normal group, $^{*}p<0.05$

Table V. The comparison of Ea between the normal and CAD group (Mean±SD).

Groups (# of cases)	Rest status	10 μg/kg.min	20 μg/kg.min	30 μg/kg.min	40 μg/kg.min
Normal (47)	9.3±1.7	9.6 ±1.8	9.7±1.6	9.2±1.9	9.5±1.8
CAD (51)	9.2±1.9	9.1 ±2.1	9.2±1.9	9.3±1.9	9.7±2.1

Comparison with normal group, $^{*}p<0.05$

group. The mean Aa didn't have a statistical difference between the two groups until the dose of Dob had got to the 40 μg/kg·min. It suggested that the systolic and the diastolic velocity of mitral annulus could find the change of the compensatory cardiac function of the older CAD patients sensitively. Moreover, when the dose of Dob got to 20 μg/kg·min, the systolic function and active diastolic function of left ventricle had decreased. This suggested that the compensatory cardiac function had begun to decrease when the hearts of the elderly CAD patients were in middle loading status. Therefore, the exercise intensity should limit to be less than middle load status, so that the cardiovascular accidents could be avoided.

From the results, it could be concluded that when used the method of combination of DSE and TDI, we could add the Dob dose of 20 μg/kg·min directly, which could reduce the total dose of Dob and prevent the patiens from the adverse events, such as the increasing of blood pressure, malignant arrhythmia, headache and so on. Meanwhile, it could be found that the mean Sa and Ea of mitral annulus could help find the change of the cardiac systolic and diastolic function of the CAD people sensitively. However, the mean Aa of the mitral annulus could not reflect the change of the diastolic function in the CAD patients.

We still had some limitations in our study. (1) the sample size was not big enough; (2) Due to the angle limitation of TDI, the method couldn't be applied to the short axis of left ventricle; (3) The faster heart rate and the poor quality of the images could have impacts on the measurement results; (4) We didn't perform the repeatability test of in the observers because the patients were not suitable to accept two stress echocardiography in the same time range.

The sample size could be increased to make the conclusion more reliable and statistically significant. 2D strain imaging, instead of TDI, could be employed to assess the short axis of left ventricle, as the application of TDI is limited by its view angle. Also, the future improvement of ultrasonic instrument, including picture frequency, resolution and contrast, can increase the quality of ultrasonic imaging and affect the diagnosis of cardiac function positively.

Conclusions

In a word, the mean Sa and Ea of the mitral annulus that was measured through the method of combination of the DSE and TDI could find the change of the cardiac systolic and diastolic function of the elderly CAD patients, which had large potential in the clinical application in future.

Conflict of Interest

The Authors declare that they have no conflict of interests.

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