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Myocardial Stratified Strain Technique on Left Ventricular Systolic Function in Essential Hypertension

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Abstract: *Objective: To study and analyze the clinical application value of myocardial stratification strain technique on the functional changes of the left ventricular triple layer myocardium in patients with essential hypertension. Methods: Thirty patients with essential hypertension, 30 hypertensive patients with left ventricular hypertrophy diagnosed by electrocardiography or by ultrasound, 30 hypertensive patients without left ventricular hypertrophy and 30 patients with normal blood pressure were selected as the control group. Two-dimensional dynamic images of the basal, intermediate and apical segments of the left ventricle were acquired in short-axis views over three consecutive cardiac cycles using a Philips ultrasound instrument. The CS of each layer of myocardium in the basal, intermediate and apical segments of the left ventricle was determined using the circumferential stratified strain technique and the strain values were compared between the three groups. Results: 1. The absolute value of CS in each layer of myocardium from the endocardium to the epicardium decreased layer by layer in the control, NLVH and LVH groups. 2. The absolute values of CS in the middle and basal segments of each layer were lower in the control, NLVH and LVH groups than in the apical segments. 3. Compared with the control group, the absolute values of CS in all layers of the subendocardial, basal and intermediate segments of the apical segment were slightly reduced in the NLVH group without statistical significance ($P>0.05$), and the absolute values of CS in the mid and subepicardial segments of the apical segment were lower than those of the control group, but the differences were not statistically significant ($P<0.05$); the absolute values of CS in the apical, basal and intermediate segments were reduced in the LVH group with statistical differences ($P<0.05$). 4. Compared with the NLVH group, the LVH group showed a significant reduction in the absolute CS values of the layers of the apical segment, the middle and outer layers of the intermediate segment and the middle and outer layers of the basal segment, and a reduction in the absolute CS values of the inner layers of the basal and intermediate segments, but the difference was not statistically significant ($P>0.05$). Conclusion: The stratified strain technique can quantitatively evaluate the local and global systolic function of the left ventricular myocardium in a stratified manner. It can evaluate the altered function of the left ventricular myocardium in all layers of hypertensive patients with altered left ventricular configuration, and is expected to provide a new method for quantitative clinical evaluation of abnormal left ventricular systolic function.*

Keywords: *Stratified strain technique; Essential hypertension; Circumferential layering strain*

1. Introdnction

Hypertension is one of the major risk factors for cardiovascular disease and is currently one of the leading causes of death in many countries [1]. As hypertension progresses, the volume load (preload) increases, ventricular volume becomes larger, myocytes grow in series, myocardial cells become longer, the ventricular wall thickens, the ventricles become dilated and hypertrophied, followed by left ventricular hypertrophy (LVH), myocardial compliance decreases, and cardiac structure and function change [2]. Speckle tracking echocardiography (STI) is based on standard 2D grey-scale images that track the spatial motion of echogenic speckles within the myocardium in real time [3], allowing the motion of different pixels of myocardial tissue within the region of interest to be tracked frame by frame, reflecting the trajectory of myocardial motion and the degree of deformation of myocardial motion [4]. The stratified strain technique is a more accurate strain analysis technique developed based on 2D-STI [5], which is able

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to analyse the myocardial left ventricle in three layers of myocardium and assess the overall or local function of the ventricle in a stratified manner, so as to understand the changes in left ventricular heart function in healthy and hypertensive populations [6], and to analyse the clinical application value of the myocardial stratified strain technique in patients with essential hypertension who have different left ventricular configurations.

2. Manuscript Preparation

2.1. Study Subjects

Patients with clinically diagnosed primary hypertension, 30 hypertensive patients with left ventricular hypertrophy by electrocardiography or diagnosed by ultrasound, 30 hypertensive patients without left ventricular hypertrophy and normal blood pressure in the same period were collected from December 2019 to January 2021 at the Cardiovascular Department of the Affiliated Hospital of Shaanxi University of Chinese Medicine Thirty were used as the control group. Inclusion criteria: (1) left ventricular ejection fraction (LVEF)≥50%; (2) age 25-65 years; (3) patients with essential hypertension were divided into two groups according to the diagnostic criteria of left ventricular mass index (LVMI): non-left ventricular hypertrophy (NLVH) group and left ventricular (LVH) group; (5) complete clinical data. Exclusion criteria: (1) definite diabetes mellitus, significant liver and kidney disease; (2) heart valve disease, pericardial disease, etc. on ultrasound; (3) chronic obstructive pulmonary disease; (4) other such as anaemia, cancer, systemic diseases, etc.

2.2. Apparatus and methods

2.2.1. Examination instruments

Philips EPIQ 7C colour Doppler ultrasound diagnostic instrument, 2D probe S5-1, frequency 2.0-4.5MHz, frame rate 50-70 frames/s, Department of Ultrasound Diagnosis, Affiliated Hospital of Shaanxi University of Traditional Chinese Medicine.

2.2.2. Examination method

The patient is placed in the left lateral recumbent position in a quiet state, and the ECG is connected to the chest leads simultaneously. Routine echocardiography is performed to measure basic cardiac parameters: left atrial internal diameter (LAD), left ventricular end-diastolic internal diameter (LVIDd), septal thickness (IVSD), left ventricular posterior wall thickness (LVPWD), left ventricular mass index (LVMI) and left ventricular ejection fraction (LVEF). Determine the examination views: 2D grey-scale dynamic images of the LV short-axis mitral valve, intermediate segment and apical level views for 3 consecutive cardiac cycles, stored on the instrument, using the Echo PAC workstation, to analyse the dynamic images and select the 2D Strain function for parasternal LV short-axis mitral valve, papillary muscle and apical level images. The strain curve, strain value and peak time of the CS corresponding to the cardiac cycle of the inner, middle and outer myocardium of the basal, middle and apical segments are automatically displayed by clicking on the calculation and the system automatically calculates the CS values of the inner, middle and outer myocardium of the left ventricle as a whole and the CS values of the whole left ventricle as a whole, and can display the corresponding bull's eye diagram. Finally, typical images are selected and saved to the hard disk, and the data are recorded for statistical analysis.

2.3. Statistical analysis

Statistical analysis was performed using SPSS 25.0 software, and the mean ($\bar{x}$) and standard deviation(s) were used for measures that were normally distributed and with equal variance. significance.

3. Results

3.1. Basic data

3.1.1. Number of people studied

A total of 90 eligible patients with essential hypertension who came to our hospital from 2019.12 to 2021.01 were included in this study, including 30 patients in the non-left ventricular hypertrophy group, 16 males and 14 females, aged 24-63 (41.38±8.96) years, and 30 patients in the left ventricular

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hypertrophy group, 19 males and 11 females, aged 28-62 (43.97±11.82) years. In the control group, there were 30 cases, 17 males and 13 females, aged 24-65 (40.35±9.62) years.

3.1.2. Comparison of basic parameters of general information

The statistics of the basic parameters of the general data of the subjects in the three groups. The analysis showed that there was a statistically significant difference in blood pressure in the NLVH group compared to the control group (P<0.05), and no statistically significant difference in age, weight, height, BMI and heart rate in the NLVH group (P>0.05);

There was a statistically significant difference in blood pressure in the LVH group compared to the NLVH group (P<0.05), and there was no statistically significant difference in age, weight, height, BMI and heart rate in the LVH group (P>0.05) (Table 1).

Table 1: Comparison of basic parameters among the three groups of examinees

	Control group(n=30)	NLVH group(n=30)	LVH group(n=30)	P
Age	40.35±9.62	41.38±8.96	43.97±11.82	0.80
weight	60.52±11.23	64.39±0.12	64.50±4.13	0.20
Height	1.64±0.10	1.67±0.08	1.67±0.07	0.33
BMI	1.71 ±0.42	1.78 ±0.35	1.92±0.15	0.68
BP	116.74±6.92 81.28±3.20	154.09±10.43* 102.52±14.60*	166.62±23.52*# 112.85±12.00*#	0.00
Heart rate	70.68 ±4.20	71.05±6.02	74.20±5.89	0.49

Note: *P<0.05 represents data compared with data from the control group.

#P<0.05 data compared with data from NLVH group.

3.2. Comparison of conventional echocardiographic parameters

The conventional echocardiographic parameters of the three groups of subjects were counted. Analysis and comparison showed that there were statistically significant differences in IVSd, LVPD and LVMI in the NLVH group (P<0.05), and no statistically significant differences in LAD and LVIDd in the NLVH group (P>0.05), when compared with the control group.

There were statistically significant differences in LVIDd, IVSd, LVPDd and LVMI in the LVH group compared to the NLVH group (P<0.05), and no statistically significant differences in LAD in the LVH group (P>0.05) (Table 2).

Table 2: Comparison of conventional echocardiographic parameters among the three groups of subjects

	Control group(n=30)	NLVH group(n=30)	LVH group(n=30)	P
LAD	32.87±2.97	33.45±2.96	35.98±9.62	0.00
LVIDd	47.36±6.82	48.94±5.63	51.28±2.97*#	0.00
IVSd	9.01±5.29	9.49±2.98*	10.67±8.98*#	0.03
LVPWd	8.90±0.51	10.12±3.84*	12.97±0.25*#	0.01
LVMI	86.65±5.10	89.96±13.78*	129.89±0.87*#	0.00
EF	64.38±5.20	63.89±2.97	63.40±4.29	0.00

Note: *P<0.05 represents data compared with data from the control group.
#P<0.05 data compared with data from NLVH group.

3.3. Comparison of three groups of layered strain parameters

The absolute values of CS in each layer of the myocardium from the endocardium to the epicardium decreased layer by layer in the control, NLVH and LVH groups.

The absolute values of CS in the middle and basal segments of each layer in the control, NLVH and LVH groups were lower than those in the apical segments.

Compared with the control group, the absolute values of CS in all layers of the subendocardial, basal and intermediate segments of the apical segment were slightly reduced in the NLVH group without statistical significance (P>0.05), and the absolute values of CS in the mesocardium and subepicardium of the apical segment were lower than those of the control group, but the differences were not statistically significant (P<0.05).

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The absolute values of CS in the apical, basal and intermediate segments were reduced in the LVH group, with statistically significant differences (P<0.05).

Compared with the NLVH group, the absolute values of CS in the apical, middle and outer layers of the middle and outer layers of the basal segment were significantly lower in the LVH group, while the absolute values of CS in the basal and inner layers of the middle segment were reduced, but the difference was not statistically significant (P>0.05) (Table 3).

Table 3: Comparison of circumferential strain parameters among the three groups of examinees

	Control group(n=30)	NLVH group(n=30)	LVH group(n=30)	P
LPS-endo(%)	-23.23 ±1.68	-21.36±2.18*	-21.02 ±1.34*#	0.00
LPS-mid(%)	-20.50 + 1.68	-18.74 + 2.05	-17.6±1.25*#	0.01
LPS-epi(%)	-17.52±1.60	-16.44±2.01	-16.25±0.93*	0.046
GLPS(%)	-20.87±1.70	-18.76±2.04*	-17.96±1.17*#	0.00

Note: *P<0.05 represents data compared with data from the control group.
#P<0.05 data compared with data from NLVH group.

4. Discussion

Prolonged and sustained blood pressure elevation can lead to left ventricular remodelling, which is now considered to have a major impact on the prognosis of hypertension [7-8]. Commonly used techniques to measure cardiac motor function currently include tissue Doppler and measurement of cardiac LVEF values, but their measurement of the heart is currently based on the overall motion of the heart, which does not allow for local analysis of the heart and makes it difficult to detect whether the heart is damaged in early hypertensive patients. Speckle tracking technique refers to the use of high-frequency 2D ultrasound images to automatically identify and track the spatial motion of myocardial echo spots, which can reflect the local motion and degree of deformation of the myocardium, quantitatively assess the motion of the myocardium, and evaluate the overall and local myocardial function of the left ventricle [9]. Stratified strain technology is a new technique based on 2D-STI technology for evaluating myocardial function, allowing for a quantitative examination of the myocardium in a stratified fashion, providing an early and more accurate picture of the extent of myocardial involvement [10].

Myocardial circumferential strain is mainly the result of contraction of the middle circular myocardial fibres. In this study, using the circumferential stratification strain technique, it was found that the layers in the control, NLVH and LVH groups were still the highest in the inner myocardium and the lowest in the outer myocardium, consistent with the results of longitudinal strain. Compared with the control group[11], the absolute values of CS in the apical subendocardial, basal and intermediate layers were slightly lower in the NLVH group, which was not statistically significant (P>0.05). The apical segment is the closest to this centre and therefore has the greatest degree of deformation and the highest absolute value of strain, whereas the basal segment is the furthest from the centre and therefore has the least degree of deformation, therefore the basal segment is the latest to show cardiac changes, the mid and outer membranes of the apical segment decline in the early phase compared to the basal and middle segments, suggesting that the systolic function of the apical segment begins to decline from the outer layer in the early phase of hypertension [12, 13]. The results show that the myocardium as a whole is less affected in the early stages of hypertension, probably because the circumferential myocardium, which is responsible for circumferential motion, is mainly located in the middle layer, and the middle layer is less affected, so there is no statistically significant difference in circumferential strain in NLVH [14]. All layers of the apical segment at LVH show a significant decrease in all three layers, as do the middle and basal segments [15], indicating that at LVH, the heart of hypertensive patients is severely damaged compared with normal subjects. The ventricular remodelling was more pronounced. Compared with the NLVH group, the LVH group showed a significant decrease in the absolute CS values of the layers of the apical segment, the middle and outer layers of the intermediate segment and the middle and outer layers of the basal segment, and a decrease in the absolute CS values of the inner layers of the basal and intermediate segments, but the difference was not statistically significant. The results verify that the damage occurs gradually in the order of the outer to inner membranes during circumferential motion of the heart, and that the basal and intermediate segments are also preserved, indicating that the basal segment of the heart in hypertensive patients is the last damage to occur [16]. In Wei Changhua's study it was shown that it was also believed that the movement of the heart decreases from the outer layer in the early stages of hypertension, which is consistent with the results of the present study [17], indicating that circumferential movement is dominated by the movement of the middle endocardium and that it is damaged from the apex, the results of which may be related to the structure of the apex itself [18,19].

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