

The significance of tissue doppler imaging in the diagnosis of left ventricular diastolic function.

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Abstract

Objective: Using tissue Doppler imaging (Tissue doppler imaging, TDI) to detect mitral annulus velocity in patients with hypertension and compared with blood flow Doppler method. This research was aimed to explore the new method to evaluate left ventricular diastolic function in patients with hypertension.

Methods: One hundred of hypertensive patients in our hospital were enrolled from March 2015 to June 2015. Mitral and tricuspid annular early diastolic velocity (Ea), and late diastole (Aa), and Ea/Aa of hypertension patients were detected by TDI. Early diastolic flow velocity (E), late diastolic velocity (A) and E/A were detected by mitral blood Doppler. And 50 healthy subjects were selected as the control group.

Results: Mitral blood Doppler: The difference between E/A of abnormal relaxation type and limit abnormal type diastolic function decline patients (0.59 ± 0.13 , 2.24 ± 0.17) with control group (1.23 ± 0.11) has statistically significant ($P < 0.05$). The difference between each index of Pseudonormalization (91.20 ± 7.12 cm/s, 69.17 ± 6.06 cm/s, 1.27 ± 0.08) with control group (85.90 ± 9.21 cm/s, 67.78 ± 8.77 cm/s, 1.23 ± 0.11) is not significant ($P > 0.05$). TDI: The difference of Ea/Aa of relaxation type diastolic function decline patients (0.59 ± 0.06) and Pseudonormalization (0.55 ± 0.04) with control group (1.38 ± 0.07) has statistically significant ($P < 0.05$). The difference of Ea and Aa of limit abnormal type diastolic function decline patients (4.01 ± 0.31 cm/s, 3.17 ± 0.24 cm/s) with control group (15.12 ± 0.87 cm/s, 10.12 ± 0.53 cm/s) is significant ($P < 0.05$).

Conclusions: Compared to the blood flow Doppler technique, TDI is more sensitive detection of mitral annulus spectrum hypertension patients. Accurately reflecting the change of mitral annulus diastolic velocity plays important roles in the evaluation of left ventricular diastolic function.

Keywords: Tissue Doppler imaging; Left ventricular diastolic function.

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Introduction

Hypertension was a common disease in clinic, which was also known as high blood pressure. Long-term high blood pressure is a major risk factor for heart failure, coronary artery disease, heart failure, stroke, and vision loss [1]. The severe disease can lead to heart failure, mainly including contraction dysfunction. The relaxation dysfunction usually happened before contraction dysfunction. The early detection of diastolic function change was valuable for clinic by preventing the development of hypertension and establishing correct treatment measures [2,3]. Left ventricular diastolic dysfunction is an earlier alteration for many cardiovascular diseases [4]. Left ventricular diastolic dysfunction might be caused by any kind of heart disease that leads to pericardial effusion and/or myocardial structural alteration [5].

Therefore, how to accurately evaluate left ventricular diastolic function was important. Left ventricular diastolic properties were first determined invasively using the rate of left ventricular relaxation time constant, measurements of

myocardial and chamber stiffness, and left ventricular pressure decline. Currently, noninvasive evaluation of diastolic function is applied in the day-to-day evaluation of left ventricular function [6]. Pulsed-wave Doppler (PWD)-derived transmitral inflow patterns are commonly used for assessment of left ventricular diastolic function.

However, patients with left ventricular systolic dysfunction often have variability in PWD-derived indices of left ventricular diastolic dysfunction due to increases in LA pressure, so they are preload-dependent [7]. Tissue Doppler imaging (TDI)-derived early diastolic mitral annular velocity (E') and color M-mode (CMM) imaging flow propagation velocity (V_p) have been reported to be less load-dependent methods to assess LV relaxation [8]. TDI in evaluating left ventricular diastolic function was investigated by comparing the TDI with blood flow doppler method in this experiment. Now report as follows.

Materials and Methods

Clinical data

100 cases patients with hypertension as observation group were selected in March 2015 to June 2015 in our hospital. Inclusion criteria: when the blood pressure of a patient was in accordance to these values such as SBP>140 MMHG, DBP>90 MMHG according to the world health organization (WHO), it was diagnosed as high blood pressure. Exclusion criteria: (1) the patients with cardiovascular system function severely

impaired; (2) the patients with physical state of memory; (3) the patients with other cardiovascular disease. Research had been completed before informing and consent of the patients. The 50 normal volunteers were extracted as control group. 51 cases of male were selected as observation group. The age of them was 26 to 57 years old, the average age was (41.6 ± 5.9) years old; 28 cases of male were selected as control group. The age of them was 23 ~ 57 year old, the average age was (42.9 ± 5.5) years old. There was no difference between the two groups of patients with general information. It was comparable ($P>0.05$). The results were shown in Table 1.

Table 1. The results of comparing two groups of patients in general information.

Project	Observation group (n=100)	Control group (n=50)	Statistical value	P value
gender (male/female)	51/49	28/22	0.3343	0.5631
age ($\bar{x} \pm s$, years old)	41.6 ± 5.9	42.9 ± 5.5	1.3006	0.1954
Heart rate ($\bar{x} \pm s$, time/min)	72 ± 10	74 ± 8	1.2303	0.2205
BMI ($\bar{x} \pm s$, kg/m ²)	15.31 ± 5.97	16.66 ± 5.75	1.3215	0.1884

Methods

The patients inspected were token on the left side of the hypothesis and breathed normally. Mitral valve mouth blood flow spectrum was detected by conventional echocardiography at first: Diastolic blood flow velocity during late and early period (E, A) was detected when the sample volume was in apex four cavity edge within the tip of the mitral valve. E/A value was calculated. Mitral valve ring motion spectrum was detected by adjusting the parameters of the instrument after switched to TDI pattern: Diastolic blood flow velocity during late and early period (Ea, Aa) was detected when the sample volume was in apex four cavity edge within the tip of the mitral valve inside and outside the ring. Ea/Aa value was calculated. The instrument was checked by Aloka $\alpha 7$, color Doppler ultrasound of Mindray DC-8 imported from Japan.

Observational index

Diastolic blood flow velocity during late and early period (E, A) was detected and E/A value was calculated. Diastolic blood flow velocity during late and early period (Ea, Aa) was detected when the sample volume was in apex four cavity edge within the tip of the mitral valve inside and outside the ring and Ea/Aa was calculated.

Statistical methods

The experimental data was analyzed by SPSS19.0 professional software and shown with mean \pm standard deviation. It was calculated by T test. The standard with $P<0.05$ was used to determine whether the difference was statistically significant.

Table 2. Comparison on the E, A, E/A value in two groups of patients (s, cm/s).

Group	E	A	E/A
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Control group (n=50)	85.90 ± 9.21	67.78 ± 8.77	1.23 ± 0.11
Observation group (n=100)			
RTADFA (n=62)	52.6 ± 10.11	87.12 ± 8.14	$0.59 \pm 0.13^*$
LADFA (n=22)	90.12 ± 8.68	40.91 ± 5.16	$2.24 \pm 0.17^*$
PN (n=16)	91.20 ± 7.12	69.17 ± 6.06	1.27 ± 0.08

Note: *The difference compared with the control group was statistically significant ($P<0.05$).

Results

Comparison on the E, A, E/A value in two groups of patients

The E/A value of control group was between 1 and 2 by doppler blood flow detection. 84 cases patients with E/A abnormality in observation group were detected including 62 cases with $E/A<1$ (relaxation and tension abnormal with diastolic function abate; RTADFA) and 22 cases with $E/A \geq 2$ (limitation abnormal with diastolic function abate; LADFA). The E/A value of two kinds of patients were 0.59 ± 0.13 and 2.24 ± 0.17 . Compared with the E/A value of control group (1.23 ± 0.11), it had significant difference with statistically significant ($t=27.7129, 30.1541, P<0.05$). The E/A value of 16 cases in observation group was detected between 1~2 (pseudo normalization; PN). There was no statistically significant difference with the observation group ($t=1.3423, P=1.3423>0.05$). The results were shown in Table 2.

Comparison on the Ea, Aa, Ea/Aa value in two groups of patients

The mitral valve ring motion spectrum of patients in control group was detected by TDI with $Ea>Aa$ and all >12 cm/s. Mitral valve movement spectrum of patients in observation

group were abnormal. 78 cases of patients with $Ea < 12$ cm/s, $Ea/Aa < 1$ (RTADFA and PN) and Ea/Aa ($0.59 \pm 0.06/0.55 \pm 0.04$) were compared with the control group with Ea/Aa (1.38 ± 0.07). The difference was statistically significant ($t=64.2922$, 44.9839 , $P < 0.05$); 22 cases of patients with $Ea > Aa$ and all < 8 cm/s (LADFA) and Ea/Aa ($0.59 \pm 0.06/0.55 \pm 0.04$) were compared with the control group with Ea/Aa (15.12 ± 0.87 cm/s/ 10.12 ± 0.53 cm/s). The difference was statistically significant ($t=58.0992$, 58.7353 , $P < 0.05$); the results were shown in Table 3.

Table 3. Comparison on the *Ea*, *Aa*, *Ea/Aa* value in two groups of patients (s, cm/s).

Group	Ea	Aa	Ea/Aa
Control group (n=50)	15.12 ± 0.87	10.12 ± 0.53	1.38 ± 0.07
Observation group (n=100)			
RTADFA (n=62)	7.12 ± 0.91	11.34 ± 0.97	0.59 ± 0.06*
LADFA (n=22)	4.01 ± 0.31*	3.17 ± 0.24*	1.23 ± 0.11
PN (n=16)	5.91 ± 0.77	11.02 ± 0.75	0.55 ± 0.04*

Note: *The difference compared with the control group was statistically significant ($P < 0.05$).

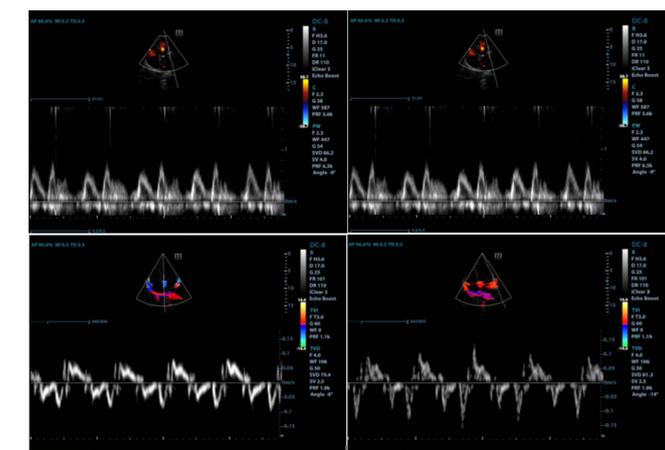


Figure 1. The results of TDI.

Observation on the spectrum image

The declining E peak and higher A peak of mitral valve ring motion spectrum with E/A dropping less than 1 were appeared when relaxation function was reduced in early period. When diastolic function decreased aggravating, the increasing left atrial pressure covered up the effect of peak E and A of mitral valve blood flow spectrum by the anomaly early relaxation of left ventricular diastolic. It made the examination results in pseudo normalized. However, pseudo normalized was identified by mitral valve ring motion spectrum with the E peak value $< A$ peak value. With the development of left ventricular diastolic function reduced further into restrictive filling, TDI on early spectrum of mitral valve ring motion velocity was significantly lower than normal. The results of test were shown in Figure 1.

Discussion

Hypertension was one of the most common diseases in clinic. The main characteristics were the increasing of systemic arterial systolic pressure and diastolic blood pressure. As a kind of high risk factors of chronic disease, hypertension can lead to a variety of cardiovascular complications [9]. Due to the increasing of systemic arterial pressure and left ventricular load, left ventricular systolic function was disorder by long-term development of the disease and without effective control. It caused heart failure at last. Several papers reported that abnormal left ventricular diastolic function was happened before abnormal systolic function [10,11]. Therefore, for clinical patients with high blood pressure and without obvious symptoms, timely and accurate assessment of left ventricular diastolic function can effectively predict the occurrence of heart failure. It was of great significance for clinical prevention and treatment.

The left ventricular diastolic dysfunction was typed into relaxation and tension abnormal with diastolic function abate, limitation abnormal with diastolic function abate and pseudo normalization, respectively according to the degree in clinic. It was characterized by reducing left ventricular relaxation function, pseudo normal filling function of left ventricular and left ventricular dysfunction [12,13]. The left ventricular function was assessed by the measurement of mitral valve blood flow spectrum with echocardiography in past clinical application. The ratio of Mitral diastolic early to late blood flow velocity (E, A) was detected for the assessment of left ventricular diastolic function. E/A value in normal was between 1-2 [14,15]. When relaxation and tension abnormal with diastolic function abate, the declining E peak and increasing A peak of mitral valve blood flow spectrum were appeared. The E/A value was not in the normal range. When diastolic function decreased aggravating, the increasing left atrial pressure covered up the effect of peak E and A of mitral valve blood flow spectrum by the anomaly early relaxation of left ventricular diastolic. It made the examination results in pseudo normalized. As a result, it lead the mitral valve flow spectrum can't make the right diagnosis [16,17].

TDI as a new clinical technique was developed in recent years. It was also called myocardial tissue doppler imaging, which was myocardial imaged by color doppler flow imaging myocardial imaging technology. Thereby, the myocardial function was observed directly. The diastolic function of heart was assessed through the analysis of the motion state of myocardial. Its principle was that as follows [18-20]: compared with the vascular blood flow velocity of ventricular wall, blood flow of the heart large blood vessels and heart cavity was much faster. It can be characterized by two different signal intensity when testing. Fast blood flow signal was filtered by DWI with room wall of blood flow signals leaving. Observation of the myocardial movement thus was realized. It help get rid of the influence of left atrial pressure. A large number of clinical data showed that [21] sensitivity of the results was as high as 90% when $Ea < 8.5$ cm/s and $Ea/Aa < 1$ was set as the standard to identify pseudo normal.

In this experiment, TDI mitral valve ring motion spectrum was compared with echocardiographic mitral valve blood flow spectrum. The results showed that the E/A change on mitral valve flow spectrum can effectively instruct the diastolic dysfunction of relaxation and tension abnormal with diastolic function abate and limitation abnormal diastolic function abate but E, A value and E/A on period of pseudo normal had no obvious difference with the normal group. It was unable to make effective diagnosis. Ea and Aa values of mitral valve ring motion spectrum in the late diastolic dysfunction had significant differences compared with normal levels. Ea/Aa value in the early diastolic dysfunction and pseudo normal period had obvious difference with control group. To sum up, TDI can effectively identify each phase of the left ventricular diastolic dysfunction and it was a reliable index for evaluation of left ventricular diastolic function.

References

1. Johnson W, Nguyen ML, Patel R. Hypertension crisis in the emergency department. *Cardiol Clin* 2012; 30: 533-543.
2. Wu J, Zhao T, Shang Z. The change on the global and local myocardial function of rapid right ventricular pacing dogs. *Shandong Med J* 2013; 53: 44-47.
3. HuaBin N, Bin Y. Investigation on the different replacement therapy effects on left ventricular structure and function in patients with uremia based on echocardiography combined tissue doppler imaging technology. *Guangdong Med J* 2013; 34: 583-585.
4. Wang H, Liu HX, Wang YL, Yu XQ, Chen XX. Left ventricular diastolic dysfunction in patients with dermatomyositis without clinically evident cardiovascular disease. *J Rheumatol* 2014; 41: 495-500.
5. Kim JK, Kim SG, Kim MG, Kim SE, Kim SJ. Left ventricular diastolic dysfunction as a predictor of rapid decline of residual renal function in patients with peritoneal dialysis. *J Am Soc Echocardiogr* 2012; 25: 411-420.
6. Wen Z, Ma H, Zhao Y, Fan Z, Zhang Z. Left Ventricular Diastolic Dysfunction Assessment with Dual-Source CT. *PLoS One* 2015; 10: e0127289.
7. Abdelmuktader AM, Azer HY. Usefulness of pulsed wave tissue doppler imaging in assessment of left ventricular functions in children with beta-thalassemia major. *Indian J Pediatr* 2013; 80: 721-725.
8. Lindblad YT, Axelsson J, Balzano R, Vavilis G, Chromek M, Celsi G, Bárányi P. Left ventricular diastolic dysfunction by tissue Doppler echocardiography in pediatric chronic kidney disease. *Pediatr Nephrol* 2013; 28: 2003-2013.
9. Nan-Nan L, Guo-Xian Q, Chun-Yan M. Evaluation of left ventricular diastolic function in patients with chronic heart failure. *Chinese J Postgraduates Med* 2012; 35: 17-21.
10. Yin X, Zhang H, Li X. clinical research on non ST-elevation acute coronary syndrome of left ventricular diastolic dysfunction based on color doppler flow imaging. *Chinese J Clin Res* 2014; 27: 731-732.
11. Li-Fang X. Assessment on left ventricular diastolic function in patients with diastolic heart failure and synchronicity of related research based on tissue doppler imaging. *Nanchang University* 2013; 22: 73-74.
12. Yu S, Wu Q, Bu J. Evaluation of the influence on left ventricular mechanical synchronicity in different parts of the pacemaker based on tissue doppler. *Chinese J Ultrasound Med* 2014; 30: 516-519.
13. Kalra A, Harris KM, Maron BA, Maron MS, Garberich RF. Relation of Doppler Tissue Imaging Parameters With Heart Failure Progression in Hypertrophic Cardiomyopathy. *Am J Cardiol* 2016; 117: 1808-1814.
14. Li Z, Cheng S, Yang B. Evaluation of left ventricular diastolic function in patients with left ventricular remodeling youth essential hypertension based on tissue doppler imaging. *Chinese J Convalescent Med* 2015; 13: 4-6.
15. Zhang BY, Ping J, Zhang L. Evaluation of single dialysis in acute effect of left ventricular function in patients with uremia based on tissue doppler imaging. *China Med Herald* 2015; 18: 153-157.
16. Suran D, Sinkovic A, Naji F. Tissue Doppler imaging is a sensitive echocardiographic technique to detect subclinical systolic and diastolic dysfunction of both ventricles in type 1 diabetes mellitus. *BMC Cardiovasc Disord* 2016; 16: 72.
17. Yao SF, Jiang CH, Tang YF. Evaluation of the influence on left ventricular function in patients with chest radiotherapy based on the E/Ea value measured by tissue doppler imaging. *Shandong Med J* 2015; 55: 36-38.
18. Jiang HY, Fu JQ. Evaluation of left ventricular diastolic function in patients with primary hypertension based on tissue doppler imaging. *Gansu Med J* 2015; 34: 438-440.
19. Gallay-Lepoutre J, Bélanger MC, Nadeau ME. Prospective evaluation of Doppler echocardiography, tissue Doppler imaging and biomarkers measurement for the detection of doxorubicin-induced cardiotoxicity in dogs: A pilot study. *Res Vet Sci* 2016; 105: 153-159.
20. Zhao XN, Liu Y, Sun MY. Tissue doppler imaging in cardiac work index quantitative assessment of left ventricular function in patients with chronic renal failure. *J Clin Exp Med* 2014; 13: 357-360.
21. Zhang BL, Wu XQ. Evaluation of the comparison of the left ventricular diastolic function based on the gated myocardial perfusion imaging and tissue doppler imaging. *Chinese Cardiovascular Dis Res* 2015; 13: 1013-1016.

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