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Evaluation of right ventricular systolic function in patients with chronic renal insufficiency with 3D-STI

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Abstract: **To evaluate the clinical value of 3D-STI in the evaluation of right systolic function in patients with chronic renal insufficiency. 34 patients with mild chronic renal insufficiency (CKD1-2 group), 44 patients with moderate to severe chronic renal insufficiency (CKD3-5 group), who accepted treatment in the West Coast of Qingdao University Affiliated Hospital from January 2016 to May 2018, and 41 healthy volunteers (control group) were enrolled. 3D-STI analysis was underwent, and the indicators, including right ventricle end-systolic volume (RVESV), right ventricle end-diastolic volume (RVEDV), three-dimensional right ventricular ejection fraction (3D-RVEF), right ventricular longitudinal strain (RVGLS) and right ventricular free wall longitudinal strain (RVFLS) were compared. Compared with the normal group, the RVEDV and RVESV in the mild group increased, while the 3D-RVEF, RVCLS, and RVFLS decreased (P>0.05). Compared with the normal group and the mild group, the RVESV and RVESV were significantly increased in the moderate to severe group, while 3D-RVEF, RVCLS, and RVFLS were significantly decreased with the statistically significant difference (P<0.05). It could be concluded that 3D-STI can detect changes in right ventricular systolic function in patients with renal insufficiency and provide valuable information for clinical treatment.**

Keywords: Ventricular function; Right; Renal insufficiency; Chronic; Speckle tracking imaging

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1. Introduction

For a long time, many domestic and abroad scholars have studied left ventricle, while neglecting that of right ventricular structure and function. But, as we know, right ventricular function plays an important role in the management of cardiovascular diseases, and the functional change is also an important decisive factor in evaluating the prognosis of diseases[1]. 3D-STI is a new kind of technique to evaluate cardiac function by calculating speckle motion curve in three-dimensional space based on speckle tracking technology[2]. The purpose of our study is to evaluate the right ventricular function in patients with CKD with 3D-STI technique to detect the right ventricular strain characteristics[3].

2. Materials and methods

2.1. Patient enrolment

Seventy-eight patients with CKD, including 40 males and 38 females aging from 23 to 70 years old (average of 45.5), were selected from January 2016 to May 2018 in the West Coast Hospital of Affiliated Hospital of Qingdao University. Inclusion criteria: Kidney function or structure changes caused by various kidney diseases for more than 3 months; No history of pulmonary hypertension before CKD. Diseases leading to pulmonary hypertension (interstitial pulmonary disease, primary pulmonary hypertension, pulmonary embolism, chronic obstructive pulmonary disease, connective tissue disease, etc.), arrhythmia, severe valvular regurgitation or stenosis, myocardial infarction, congenital heart disease and other conditions leading to changes of cardiac structure and function and poor echocardiographic image quality were excluded. According to the 2002 Guidelines for Clinical Practice of Chronic Renal Diseases in American, patients with chronic renal insufficiency were divided into mild group, CKD 1-2 stage, GFR 60-90ml/min, 34 cases; moderate-severe group, CKD 3-5 stage, GFR<60ml/min, 44 cases. Forty-one healthy subjects were selected as normal control group during the same period. There were 21 males and 20 females, aging from 24 to 70 years, with an average age of 44.1 years. There were no abnormalities in physical examination and electrocardiogram.

2.2. Echocardiographic examination

Images were obtained with the patient at left lateral decubitus position using a Philips EPIQ 7C (Philips Healthcare, MA, USA). Left ventricular ejection fraction (LVEF) and right ventricular area change fraction (RVFAC) were measured by Simpson method. Tissue motion tricuspid annular displacement (TAPSE) was measured by M-mode echocardiography on apical four-chamber cardiac section. Maximum tricuspid regurgitation velocity (V) was measured by continuous Doppler echocardiography. According to Bernoulli equation, pulmonary arterial systolic pressure (PASP) was calculated.

2.3.3. D-STI analysis

The X5-1 probe was used to adjust the mode to 3D Full-volume. The three-dimensional images of four

cardiac cycles on the standard apical four-chamber section were recorded at the end-expiratory holding state. The image was copied to TOMTEC workstation for offline analysis. The left ventricular cavity, right ventricular cavity and main pulmonary valve ring were marked respectively with the helping of the software. The software automatically could recognize the left ventricular end diastolic and left ventricular end systolic and automatically generated the right ventricular endocardial curve. Then we manually adjusted the region of interest to obtain the right ventricular end systolic volume (RVESV), right ventricular end diastolic volume (RVEDV), three-dimensional right ventricular ejection fraction (3D RVEF), right ventricular longitudinal strain (RVGLS), right ventricular free wall longitudinal strain (RVFLS).

2.4. Statistical methods

SPSS 21.0 statistical software was used. The measurement data was expressed by mean ± SD. All measurements were tested to be normal distribution. The parameters of general condition, conventional echocardiography and right ventricular radial strain were compared by one-way ANOVA, and LSD-t was used for two-way comparison between groups. P<0.05 was considered statistically significant.

3. Results

3.1. General data and conventional echocardiographic parameters

There was no significant difference in general data among the three groups (P>0.05). There was also no significant difference in IVSTd, LVEF, RVFAC, PASP and TAPSE between the mild group and the normal group (P>0.05). Comparing with the normal group and the mild group, the IVSTd and PASP in the moderate-severe group were significantly higher, while the LVEF, RVFAC and TAPSE significantly lower (P<0.05), Table 1.

3.2. Three-dimensional echocardiographic parameters

Compared with the normal group, RVEDV and RVESV increased in the mild group, while 3D RVEF, RVGLS and RVFLS decreased (Figure 1), there are no significant difference (P>0.05). RVESV and RVESV (Figure 2) increased significantly in the moderate-severe group, while 3D RVEF, RVGLS and RVFLS decreased in the mild group (P<0.05), Table 2.

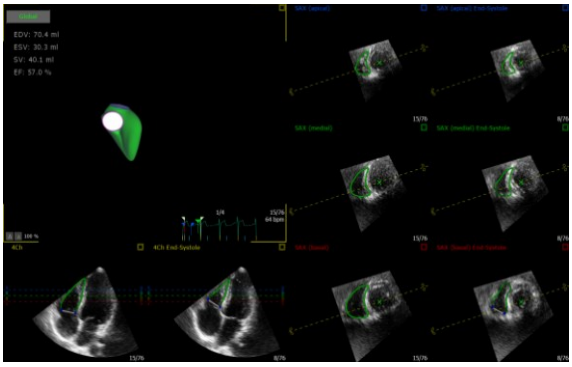

Figure 1. Three-dimensional imaging of right ventricle.

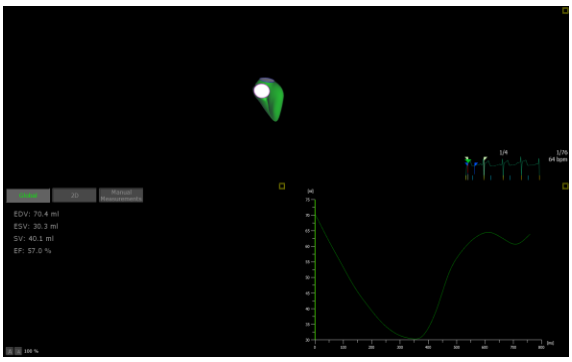

Figure 2. Three-dimensional speckle tracking technique for right ventricular time-volume curve.

Table 1. Conventional echocardiographic parameter

Items	IVSTd	LVEF	RVFAC	TAPSE	PASP
Control group	8.6±0.65	66.4±3.95	58.4±5.74	23.9±2.22	22.0±4.41
CKD1~2group	9.9±0.79	65.5±3.80	57.9±7.73	23.8±3.04	23.1±4.72
CKD3~5group	12.1±1.35*#	54.4±5.34*#	38.4±8.03*#	18.5±3.20*#	32.4±5.38*#

Values are mean ± SD, *$P<0.05$, vs control group; #$P<0.05$, vs CKD1~2group

4. Discussion

Chronic renal insufficiency (CRI) is characterized by normal and abnormal glomerular filtration rate, abnormal blood or urine components, abnormal imaging findings, or an unknown decrease of glomerular filtration rate for more than 3 months[4]. At present, chronic kidney disease (CKD) has become an important public health problem all over the world. CKD is a major risk factor for cardiovascular complications and mortality[5]. Studies have shown that[6] right ventricular function

changing plays an important role in the prognosis of patients with heart failure and myocardial infarction, and are independent predictors of cardiovascular complications mortality, either[7].

The right ventricle is the anterior chamber behind the sternum. Compared with the elliptical structure of the left ventricle, the right ventricle is triangular in the coronal section and crescent in the cross section[8]. Its special anatomical structure makes it difficult to evaluate its function. The myocardium of the right ventricle consists of two parts: the superficial circular muscle, which extends from the circular muscle of the left ventricle to form a whole, and the deep longitudinal myocardium, which plays the most important role in the right ventricular systolic function[9]. Contrary to the left ventricle, the right ventricle lacks the third oblique myocardium layer, which is consist with two layers of myocardium from the basal segment to the apical. 3D-STE is a new technique based on gray-scale full volume imaging mode to evaluate cardiac function by analyzing the movement and deformation of three-dimensional ultrasound speckles. 3D-STE technology can track the right ventricular myocardial spot motion in three-dimensional structure of the heart, which is not affected by the complex anatomical characteristics of the right ventricle. This provides a new possibility for evaluating the right ventricular function[10].

Table 2. 3D strain parameters of right ventricle

Items	RVESV	RVEDV	3D-RVEF	RVGLS	RVFLS
Control group	54.5±4.55	23.6±3.67	51.4±4.49	23.3±2.62	25.5±2.96
CKD1~2 group	55.4±6.24	24.3±5.28	50.6±5.88	22.6±3.24	24.9±3.08
CKD3~5 group	60.5±8.14*#	37.6±7.51*#	37.5±6.34*#	19.5±6.20*#	21.4±5.39*#

***$P<0.05$, vs control group; #$P<0.05$, vs CKD1~2 group**

The function of right ventricle is volume pump, which is susceptible to pressure load. In this study, patients with pulmonary hypertension were screened to determine the effect of renal dysfunction on right ventricle. Wang[11] et al. used 3D-STI technology to evaluate left ventricular function in CKD patients. It was found that the accumulation of toxins in vivo, electrolyte metabolic disorders and other factors could cause cardiomyocyte damage, hypertrophy, fibrosis and then ventricular remodeling, which can result in changes in ventricular function. This study found that IVSTd, LVEF, RVFAC, PASP and TAPSE did not change significantly in mild CKD group, while IVSTd and PASP increased significantly in CKD group, at same time, LVEF, RVFAC and TAPSE decreased significantly. It proved that with the progress of CKD going on, water and sodium retention, toxin and small molecule deposition caused by aggravation of renal function damage had impaired myocardial function[12].

Longitudinal strain of 3D-STI indicates the movement of longitudinal myocardium in the long axis direction, and the myocardial elongation is showed to be positive and shortened to be negative[13]. The results of this study showed that RVESV and RVESV in moderate-severe group were significantly higher than those in normal group and mild group, while 3D RVEF, RVGLS and RVFLS were significantly lower. Nemes[14] et al. pointed out that the right ventricular longitudinal myocardial deformation ability of uremic patients can accurately detect the right ventricular systolic function changes, earlier than the circumferential and radial direction of the myocardial deformation ability, the results are consistent with our study.

5. Conclusion

3D-STI can evaluate right ventricular myocardial dysfunction in patients with CKD, and has high sensitivity and specificity. It provides a new method for clinical evaluation of right ventricular function in patients with CKD.

References

[1] Akhavan-khaleghi N, Hosseinsabet A. Effects of vitamin D deficiency on left atrial function as evaluated by 2D speckle-tracking echocardiography[J]. 2018, 46(5):334-340.

[2] Abid L, Charfeddine S, Kammoun S. Relationship of left atrial global peak systolic strain with left ventricular diastolic dysfunction and brain natriuretic peptide level in end-stage renal disease patients with preserved left ventricular ejection fraction[J]. J Echocardiogr, 2016, 14(2):71-78.

[3] Adiguzel C, Bozkurt SU, Kaygusuz I, et al. Human herpes virus 8-unrelated primary effusion lymphoma-like lymphoma: report of a rare case and review of the literature[J]. Apmis Acta Pathologica Microbiologica Et Immunologica Scandinavica, 2009, 117(3):222-229.

[4] Altekin RE, Kucuk M, Yanikoglu A, et al.

Evaluation of left atrial function using two-dimensional speckle tracking echocardiography in end-stage renal disease patients with preserved left ventricular ejection fraction[J]. Acta cardiologica, 2012, 67(6):681-691.

[5] Cheng JF, Lee SH, Hsu RB, et al. Fulminant primary cardiac lymphoma with sudden cardiac death: A case report and brief review[J]. Journal of the Formosan Medical Association, 2018:S092966461730-7544.

[6] Chiu DYY, Abidin N, Hughes J, et al. Speckle tracking determination of mitral tissue annular displacement: comparison with strain and ejection fraction, and association with outcomes in haemodialysis patients[J]. The International Journal of Cardiovascular Imaging, 2016, 32(10):1-8.

[7] Caspar T, Fichot M, Ohana M, et al. Late Detection of Left Ventricular Dysfunction Using Two-Dimensional and Three-Dimensional Speckle-Tracking Echocardiography in Patients with History of Nonsevere Acute Myocarditis.[J]. Retour Au Numéro, 2017, 30(8):756-762.

[8] Zhong Y, Bai W, Xie Q, et al. Cardiac function in patients with polymyositis or dermatomyositis: a three-dimensional speckle-tracking echocardiography study[J]. The International Journal of Cardiovascular Imaging, 2018, 34(5):683-693.

[9] Spartera M, Damascelli A, Mozes F, et al. Three-dimensional speckle tracking longitudinal strain is related to myocardial fibrosis determined by late-gadolinium enhancement[J]. The International Journal of Cardiovascular Imaging, 2017, 33(9): 1351-1360.

[10] Du GQ, Hsiung MC, Wu Y, et al. Three-Dimensional Speckle-Tracking Echocardiographic Monitoring of Acute Rejection in Heart Transplant Recipients[J]. Journal of Ultrasound in Medicine, 2016, 35(6): 1167-1176.

[11] Wang D, Zhang L, Zeng Q, et al. Assessment of left ventricular performance in heart transplant recipients by three-dimensional speckle tracking imaging[J]. Medicine, 2017, 96(41):e8129..

[12] Fang X, Pan C, Chen Y, et al. Assessment of subclinical left ventricular changes in essential hypertensive patients with hyperuricemia: A three-dimensional speckle-tracking echocardiography study[J]. Clinical and Experimental Hypertension, 2017, 39(1):93-99.

[13] Ribeiro, José. Assessment of left atrial function by three-dimensional speckle-tracking in cardiomyopathies: A step forward?[J]. Revista Portuguesa de Cardiologia (English Edition), 2017, 36(12):915-917.

[14] Nemes A, Domsik, Péter, Kalapos A, et al. Is three-dimensional speckle-tracking echocardiography able to identify different patterns of left atrial dysfunction in selected disorders?[J]. International Journal of Cardiology, 2016, 220:535-537.

