SCIENTIFIC RESEARCH

RIGHT VENTRICULAR FUNCTION ASSESSMENT BY SPECKLE TRACKINGECHOCARDIOGRAPHY IN PATIENTS ON REGULAR HEMODIALYSIS WITH PRESERVED LEFT VENTRICULAR EJECTION FRACTION

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SUMMARY

Aims: To investigate right ventricular function in hemodialysis patients with preserved left ventricular ejection fraction (LVEF) using two-dimensional speckle tracking echocardiography.

Methods: Patients with end-stage kidney disease (ESKD) who were on regular hemodialysis and had preserved LVEF and a group of age- and sex-matched control subjects were recruited for the study in Bach Mai Hospital. All subjects were interviewed and examined comprehensively. Echocardiography was performed in all patients and controls. Right ventricular function was evaluated using conventional and speckle-tracking echocardiography. Estimate glomerular filtration rate (eGFR) was calculated according to the MDRD GFR equation.

Results: From 6/2022 to 11/2022, a total of 61 ESKD receiving hemodialysis regularly and 32 controls were evaluated. The mean age of the hemodialysis patients was 51.2±13.8. Men account for 54.1% (33/61). Hemodialysis patients had larger right ventricular diameters, lower RV fractional area change (FAC) and tricuspid annular plane systolic excursion (TAPSE), and decreased S velocities of the tricuspid valve compared to the controls ($p<0.05$ for all). Systolic pulmonary artery pressure (sPAP) of the hemodialysis group was higher when compared to the controls ($p<0.05$ for all). Absolute values of right ventricular global strain (RVGS) and right ventricular free wall strain (RVFWS) were significantly lower in the hemodialysis group than in the control ($p<0.05$ for all). Absolute values of RVGS and RVFWS inversely correlated to LV mass index ($r = -0.42$, $p<0.05$ and $r=-0.46$, $p<0.05$, respectively) while they positively correlated to eGFR ($r = 0.57$, $p<0.05$ and $r = 0.59$, $p<0.05$, respectively), hemoglobin level ($r = 0.41$, $p<0.05$ and $r = 0.43$, $p<0.05$, respectively), RVFAC ($r = 0.54$, $p<0.05$ and $r = 0.51$, $p<0.05$, respectively).

Conclusion: Right ventricular function assessed by speckle tracking echocardiography reduced in hemodialysis patients. Right ventricular myocardial strain strongly correlated with glomerular filtration rate, RVFAC, and moderately correlated with hemoglobin level and LV mass index.

Keywords: *Right ventricular function, speckle tracking echocardiography, myocardial strain, end-stage kidney disease, hemodialysis.*

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I. INTRODUCTION

Chronic kidney disease is a severe clinical issue that is becoming increasingly prevalent in Vietnam and in the world. Hypertension, diabetes, and cardiovascular diseases contribute to the increasing burden of chronic kidney disease. Cardiovascular disease (CVD) is the most important cause of adverse outcomes and mortality in end-stage kidney disease (ESKD) patients [1]. The pathophysiology of CVD in ESKD patients is complex, being related to cardiovascular risk factors, and uremia-specific processes such as alterations in phosphate and calcium metabolism, anemia, arterial dilation, and hemodynamic overload. It was previously reported that in ESKD patients who were on hemodialysis, right ventricular function decreased, which is linked to poor outcomes [2]. Different techniques including echocardiography, MSCT, MRI, catheterization… can be used to assess right ventricular function. Echocardiography is an invasive and inexpensive method allowing the comprehensive quantification of right heart chambers with the use of several echocardiographic parameters, like tricuspid annular plane systolic excursion (TAPSE), fractional area change (FAC), tricuspid annular systolic velocities. Two-dimensional speckle tracking echocardiography (2D-STE) is a new technique that helps detect early myocardial dysfunction [3,4,]. Our study aimed to investigate right ventricular function in hemodialysis patients using speckle-tracking echocardiography.

II. METHODS

Patients and materials

A cohort study of 61 patients with ESKD who were on regular hemodialysis and controls were recruited for the study in Bach Mai Hospital.

Inclusion criteria for patients' group: ESKD patients who are on regular hemodialysis.

Inclusion criteria for the controls: Volunteers from the outpatient clinic who were matched for age and sex to the patients' group.

Exclusion criteria: Left ventricular ejection fraction (LVEF) < 50%, coronary artery disease, significant valvular heart disease, congenital heart disease, moderate to severe pericardial disease, arrhythmia, non-renal causes of pulmonary hypertension, prior renal transplantation, suboptimal echocardiographic image, and patient refusal.

Ethical issue: The study was approved by the ethics committee of Bach Mai Hospital. Informed consent was obtained from each patient.

Methods

All subjects were interviewed and examined comprehensively. Clinical and blood test parameters were taken according to the study's case report form. Electrocardiography and echocardiography were performed in all patients and controls. Estimate glomerular filtration rate was calculated according to the MDRD GFR equation [1].

Echocardiography: Comprehensive two-dimensional echocardiography was performed on all subjects according to the American Society of Echocardiography guidelines [3], [4], followed by two-dimensional speckle tracking echocardiography using E95 General Electric ultrasound system (USA 2019), performed by an experienced cardiologist at about 48hours after hemodialysis. Dimensions of the right ventricle: RVDd (RV end-diastolic diameter measured on parasternal long axis view), RV basal measurement, mid cavity, and longitudinal dimensions. RV fractional area change (FAC) was computed by dividing (end-diastolic area-end-systolic area) x 100%. Systolic pulmonary artery pressure (sPAP): The systolic right ventricular pressure (sRVP) was calculated from peak TR jet velocity utilizing the simplified Bernoulli equation and trying to combine such a result with an estimation of the right atrial (RA) pressure: sRVP =4(V)2 + RA pressure, where V is the peak velocity (in m/sec) of the tricuspid valve regurgitant jet, and RA pressure is calculated using inferior vena cava (IVC) diameter and respiratory variations. Tricuspid annular plane systolic excursion (TAPSE) was calculated by passing an M-mode cursor through the tricuspid annulus and measuring the longitudinal motion of the annulus at maximum systole with a typical apical four-chamber window. The LVEF is determined utilizing the formula: EF = (EDV-ESV)/EDV. This was accomplished by Simpson's method. Tissue Doppler echocardiographic parameter: The peak annular systolic velocity (S).

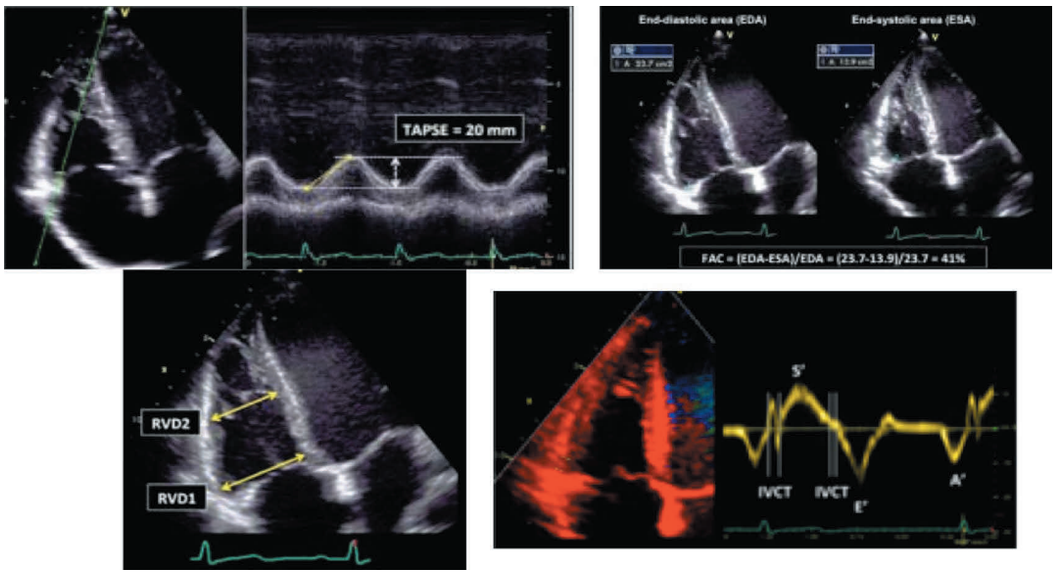

Figure 1. Conventional echocardiographic measurements of RV function

Speckle tracking echocardiography: RV global longitudinal strain (RVGS) and RV free wall strain (RVFWS) were measured on the RV-focused apical 4-chamber view using the automated function imaging (AFI) software [4].

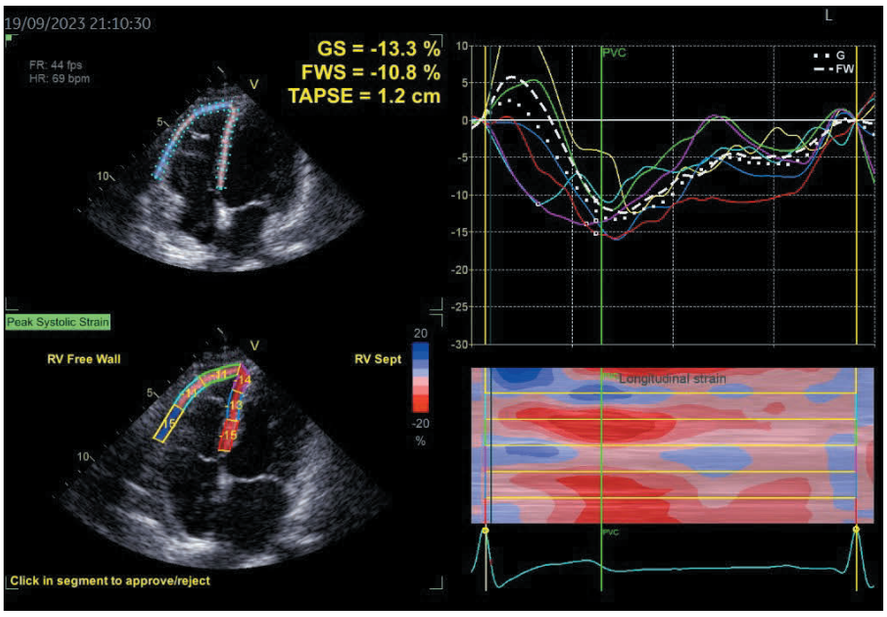

Figure 2. Measurement of right ventricular strain using two-dimensional speckle tracking echocardiography

Statistical Analysis

Data are expressed as mean ± SD or as frequencies. To compare numerical variables between two groups, the Mann-Whitney U test has been utilized. To compare categorical variables, the Chi-square test has been utilized. Correlation analysis was conducted as needed using Pearson or Spearman correlation. If the p-value is < 0.05, it is deemed significant.

III. RESULTS

From 6/2022 to 11/2022, a total of 61 ESKD receiving hemodialysis regularly and 32 age- and sex-matched controls were evaluated. The mean age of the hemodialysis patients was 51.2 ± 13.8. Men 54.1% (33/61), women 45.9% (28/61). Table 1 showed that the mean age did not significantly differ between groups. The frequencies of male gender, hypertension, diabetes, and smoking were similar in both groups. Additionally, BMI, heart rate, systolic and diastolic blood pressure values were not significantly different in both groups.

Table 1. Patients' characteristic results

Parameters	Hemodialysis patients (n = 61) X ± SD or n (%)	Controls (n = 32) X ± SD or n (%)	p
Age (year)	51.2 ± 13.8	50.5 ± 14.7	>0.05
Men	33 (54.1%)	17 (53.1%)	>0.05
BMI (kg/m^2)	22.7 ± 10.5	21.6 ± 9.8	>0.05
Hypertension	41 (67.2%)	21 (65.6%)	>0.05
Diabetes	24 (39.3%)	13 (40.65)	>0.05
Smoking	11 (18.0%)	6 (18.8%)	>0.05
Systolic blood pressure	131.5 ± 32.7	129.8 ± 27.5	>0.05
Diastolic blood pressure	79.9 ± 21.6	76.3 ± 18.9	>0.05
Heart rate (beat per minute)	81.9 ± 10.3	79.8 ± 11.7	>0.05
Hemoglobin	97.4 ± 16.3	146.7 ± 11.2	**<0.05**
Urea (mmol/l)	18.4 ± 4.8	5.7 ± 1.8	**<0.05**
Creatinin (umol/l)	432.7 ± 265.6	67.9 ± 15.3	**<0.05**
eGFR (ml/min/1.73m^2)	13.9 ± 57	102.8 ± 8.6	**<0.05**

In comparison with the controls, the hemodialysis patients had a higher level of hemoglobin (p<0.001), urea (p<0.05), and creatinine (p<0.001).

Table 2. Conventional echocardiographic parameters

Parameters	Hemodialysis patients (n = 61) X ± SD	Controls (n = 32) X ± SD	p
RVDd (mm)	23.5 ± 5.3	19.9 ± 2.4	<0.05
RV longitudinal diameter (mm)	66.3 ± 10.5	57.3 ± 9.2	<0.05
RV mid cavity diameter (mm)	26.7 ± 7.9	21.6 ± 4.8	<0.05
RV basal diameter (mm)	39.3 ± 4.6	28.7 ± 5.5	<0.05
TAPSE (mm)	20.4 ± 4.5	24.6 ± 3.4	<0.05
RVFAC (%)	41.4 ± 5.6	46.7 ± 6.5	<0.05
Tricuspid S wave velocity (cm/s)	11.5 ± 3.5	14.5 ± 2.5	<0.05
sPAP (mmHg)	49.3 ± 12.4	22.5 ± 7.2	<0.05
LVEF (%)	66.7 ± 13.4	67.5 ± 12.9	>0.05
LV mass index (g/m^2)	158.5 ± 29	71.5 ± 23.7	<0.05

Hemodialysis patients had larger right ventricular diameters, lower RVFAC and TAPSE, and decreased S velocity of the tricuspid valve compared to the controls (p<0.05 for all). sPAP of the hemodialysis group was higher when compared to the controls (p<0.05 for all) (table 2).

Table 3. Speckle tracking echocardiographic parameter of RV function

Parameters	Hemodialysis patients (n = 61) X ± SD	Controls (n = 32) X ± SD	p
RVGS (%)	-14.5 ± 4.3	-22.7 ± 4.1	**<0.05**
RVFWS (%)	-15.7 ± 10.5	-23.3 ± 5.4	**<0.05**

Table 3 showed that absolute values of right ventricular global strain (RVGS) and right ventricular free wall strain (RVFWS) were significantly decreased in the hemodialysis group compared to the controls. Both the mean absolute value of RVGS and the mean absolute value of RVFWS were below the normal range.

Table 4. Correlation between RVGS, RVFWS, and clinical and echocardiographic parameters

Parameters	RVGS		RVFWS	
	r	p	r	p
Age (year)	-0.28	<0.05	-0.27	<0.05
eGFR (ml/min/1.73m^2)	0.57	<0.05	0.59	<0.05
Hemoglobin (g/l)	0.41	<0.05	0.43	<0.05
RVFAC (%)	0.54	<0.05	0.51	<0.05
LVEF (%)	0.25	<0.05	0.26	<0.05
LV mass index (g/m^2)	-0.42	<0.05	-0.46	<0.05

Absolute values of RV global strain and RV free wall strain are inversely linked to age and LV mass index while they exhibited a significant positive connection with eGFR, hemoglobin level, RVFAC, and LV ejection fraction (table 4).

IV. DISCUSSION

In patients with chronic kidney disease, a functional right ventricle is important for maintaining low venous pressure (significantly below the plasmatic oncotic pressure) as well as adequate cardiac output, either of which might mediate associations between RV dysfunction and CKD [2]. In hemodialysis patients, RV dysfunction is frequent [2]. Furthermore, because of the interventricular contact, RV dysfunction may influence LV function. RV dysfunction detection will aid in the identification of patients with a higher cardiovascular risk. Hence, a precise and efficient technique for evaluating RV function is needed. TAPSE and the RVFAC were the most often utilized echocardiographic measures in previous RV function investigations. Speckle tracking echocardiography is a new technique that helps detect subtle changes in right ventricular mechanical function even when other parameters are still in the normal range [4]. Our study showed that ESKD patients who are on regular hemodialysis tended to have larger right ventricular diameters, lower RVFAC and TAPSE, and decreased S velocities of the tricuspid valve compared to the controls (p<0.05 for all). In particular, absolute values of RV global strain and RV free wall strain were significantly decreased in comparison with the control group and were below the normal ranges [5]. In 2015, Karavelioglu et al assessed RV functions in non-diabetic, normotensive hemodialysis patients and discovered that ESRD patients had a lower FAC than the controls, this was due to decreased RV systolic function [6]. Tamulenaite et al. in 2018 found that ESRD who were on dialysis had radial RV distortion

reduced RV longitudinal function (decreased RVGS) and increased right atrial volume index [7]. In 2016, Ali et al investigated RV function in hemodialysis patients who had newly diagnosed hyperuricemia with maintained systolic function and found that the hemodialysis RV global longitudinal strain was significantly decreased in these patients [8]. In our study, there were strong correlations between absolute values of RV global strain, RV free wall strain, and estimated glomerular filtration rate eGFR ($r = 0.57$, $p<0.05$ and $r = 0.59$, $p<0.05$, respectively), strong correlations between absolute values of RV global strain, RV free wall strain and RVFAC ($r = 0.54$, $p<0.05$ and $r = 0.51$, $p<0.05$, respectively). We also found moderate correlations between absolute values of RV global strain, RV free wall strain, and hemoglobin level ($r = 0.41$, $p<0.05$ and $r = 0.43$, $p<0.05$, respectively) and LV mass index ($r = -0.42$, $p<0.05$ and $r = -0.46$, $p<0.05$, respectively). Other studies also found that there was a correlation between RV echocardiographic function with eGFR, RV dysfunction was cross-sectionally associated with CKD and prospectively predicted survival in outpatients with chronic systolic heart failure [9]. Speckle-tracking echocardiography allows evaluation of myocardial mechanics in an angle-independent fashion, which brings better performance in the assessment of heart chamber function compared to conventional echocardiography. In our study, the mean absolute values of RVGS and RVFWS were below the normal range while other RV function parameters had preserved mean values. RVGL and RVFWS changed earlier than other RV parameters. Tasana in 2021 suggested that a low value of RV strain carries the burden of mortality in hemodialysis patients, independent of any other aggravating or ameliorating factor [10].

V. CONCLUSION

Right ventricular function assessed by speckle tracking echocardiography reduced in hemodialysis patients. Right ventricular myocardial strain strongly correlated with glomerular filtration rate, RVFAC, and moderately correlated with hemoglobin level and LV mass index.

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