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Cardiology

Assessment of Right Ventricular Function Using 2D Speckle Tracking Echocardiography in End Stage Renal Disease Patients on Regular Dialysis

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ABSTRACT

Background: Chronic kidney disease (CKD) seems to be a serious issue which is becoming increasingly prevalent worldwide. The prevalence of hypertension, DM, and cardiovascular illnesses all contribute to an increase in the burden of CKD.
Aim of the study: to assess the RV functions in chronic hemodialysis patients using speckle tracking echocardiography as a noninvasive method of assessment.
Patients and Methods: This study included 50 patients on chronic hemodialysis (group I) were compared with 10 healthy individuals (group II) of matched age and gender.
Results: Right ventricular global longitudinal strain (RVLS) was significantly reduced in hemodialysis patients. RVLS was shown to be significantly inversely related to age and RV diameters (longitudinal diameter and mid cavity diameter) and tricuspid E/A ratio. While it showed significant positive correlation with FAC and LV ejection fraction. The E wave velocity of the tricuspid valve and the tricuspid E/A ratio were both substantially lower in group I patients. The A\ wave velocity of the tricuspid valve was considerably higher in group I patients. A significant decrease was observed in the E\ and S velocities of the tricuspid valve in group I patients, whereas the A velocities of the tricuspid valve were significantly enhanced. MPI was significantly increased in group I patients.
Conclusion: Patients with chronic hemodialysis had greater RV and RA dimensions, lower RV FAC and TAPSE and reduced RVLS. RVLS was shown to be significantly inversely related to age and RV diameters, RA maximal volume and tricuspid E/A ratio. While it showed significant positive correlation with FAC and LV ejection fraction.

Keywords: *Right Ventricular Function, 2d Speckle Tracking Echocardiography, End-Stage Renal Disease, Regular Dialysis*

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INTRODUCTION

Cardiovascular morbidity and mortality are higher in people with ESRD. The major cause of mortality in this group of people is cardiovascular disease. [1]

Previous studies revealed that in individuals with chronic renal failure, systolic RV function and diastolic function both decrease, which is linked to poor clinical results.[2]

A variety of techniques, including catheterization, MRI, and echocardiography, can be utilized to evaluate right ventricular function.

Numerous echocardiography parameters, like fractional area change (FAC), tricuspid annular systolic velocities, tricuspid annular plane systolic excursion (TAPSE), and myocardial performance index (MPI), have been well established for evaluating right ventricle systolic and diastolic function.[3]

A study revealed that strain analysis of the RV and RA in two dimensions may be utilized to assess the right heart's physio-mechanics. Furthermore, it may offer characteristics that are not dependent on load status, which is very beneficial in individuals with right heart disease.[4]

This research aimed to assess right ventricular function in chronic hemodialysis patients using non-invasive techniques like traditional, tissue Doppler, and speckle tracking echocardiography.

PATIENTS AND METHODS

This research was performed at the Cardiology Department of Sayed Galal University Hospital as a single-center, cross-sectional, comparative study from September 2020 to March 2021.

A total of 61 individuals receiving hemodialysis on a regular basis were evaluated. Six patients were eliminated owing to valvular and ischemic heart disease, three patients were removed due to atrial fibrillation, and two patients have been ruled out owing to bad picture quality. The final study population included 50 patients (group I) who were matched by gender, age, and risk factors to ten patients (group II). The ethics council of Al-Azhar University's Faculty of Medicine approved the study after patients who participated in the research gave their informed consent.

The study included individuals over the age of 18 who had ESRD and were on continuous hemodialysis. Patients with one or more of the following conditions were barred from participating in the study: left ventricular systolic dysfunction [EF50%], coronary arteries, moderate to severe pericardial disease, congenital heart disease, significant valvular heart disease, non-sinus rhythm, prior renal transplantation, non-renal causes of pulmonary hypertension, suboptimal echocardiographic image, and patient refusal.

All patients underwent a complete physical examination, which included taking their age, gender, DM, HTN, and smoking, as well as a full clinical investigation, which included taking their pulse and measuring their blood pressure (systolic and diastolic) and cardiac auscultation and laboratory investigation: CBC, lipid profile, kidney function tests, and electrolytes.

Electrocardiography: Patients' heart rate and rhythm were assessed using a 12-lead surface ECG with a paper speed of 25 mm/s and an amplification of 10 mm/mv to rule out ischemic or other ECG changes.

Echocardiography: The images were all taken with the patients in the standard left lateral position with a stable ECG reading.

Conventional echocardiographic parameters:

Right atrial diameters: In the apical 4 chamber view, the right atrium's maximum long axis was measured parallel to the inter-atrial septum, and the minor axis was measured as the line connecting the midlevel of the right atrium free wall to the inter-atrial septum and running perpendicular to the long axis at the mid atrial level.[5]

Dimensions of the right ventricle: RV basal measurement (in the basal one-third), mid cavity (at the LV papillary muscles' level), and longitudinal dimensions on a 4-chamber right ventricle-focused image must be performed in people with right-sided cardiac illness. [6]

FAC in the right ventricle is computed by dividing (end-diastolic area-end-systolic area) by 100 and expressed as a percentage. FAC is produced in the apical 4 chamber view by tracing the endocardium of the right ventricular in systole and diastole. [7]

Pulmonary artery systolic pressure (PASP): The right ventricular systolic pressure (RVSP) was calculated from peak TR jet velocity utilizing the simplified Bernoulli equation and trying to combine such a result with a guesstimate of the RA pressure: RVSP = 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 IVC diameter and respiratory variations. [8]

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. [(8)]

The left ventricular ejection fraction (LVEF) is determined utilizing the formula: (EDV-ESV)/EDV = EF. This was accomplished by amending Simpson's rule. [9]

Tissue Doppler echocardiographic parameters:

The peak annular systolic velocity (S), early (E') and late (A') peak annular diastolic velocities, and systolic velocity period have been calculated using the ejection time (ET), isovolumetric relaxation time (IVRT, time between the end of ET and the starting of E''), and isovolumetric contraction time (IVCT, time between the end of A' and the starting of ET).

To get a global evaluation of the RV's systolic and diastolic functions, the TDI-derived MPI was computed by dividing the total of IVCT and IVRT by the ET. [10]

Speckle tracking echocardiography:

RV global longitudinal strain: At end-systole, the RV free wall's endocardial boundary was manually traced and automatically modified to accommodate the whole myocardium. To guarantee appropriate tracking, the thickness of the myocardium was manually adjusted to the area of interest.[11]

The strain rate and RV strain are important characteristics to consider when evaluating the RV's systolic function on a global and regional scale. The percentage of RV free wall shortening from base to apex during systole is defined as the longitudinal strain rate. [(12)]

SPSS vs.25 was used for data administration and statistical analysis. Means and standard deviations have been utilized to sum up numerical data. Numbers and percentages have been utilized to summarize categorical data. 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. The letter "r" denotes the correlation coefficient. This study's p values were all two-sided. If the P value is < 0.05, it is deemed significant.

RESULTS

		Group I (n = 50)	Group II (n = 10)	P value
Age (years)	Mean ±SD	52 ±9.	50 ±4.	0.190
Sex	Male n (%)	30 (60%)	5 (50%)	0.277
	Female n (%)	20(40%)	5(50%)	
BMI	Mean ±SD	28.58±5.23	28.20±5.98	0.838

Table 1: Patient's demographics. Regarding age and gender, both groups were similar.

	Group I(n=50)	Group II(n=10)	P value
DM	21 (42%)	3 (30%)	0.280
HTN	28 (56%)	5 (50%)	0.565
Smoking	10 (20%)	2 (20%)	0.4
SBP (mmHg)	116 ±13	116 ±14	0.971
DBP (mmHg)	73 ±10	72 ±11	0.626
Hb	9.97±1.00	12.10±1.54	<0.001**
Urea	93.20±100.32	26.50±5.06	0.041*
Creatinin	5.19±1.43	0.86±0.19	<0.001**

Table 2: Both groups' risk factors and clinical characteristics: Both groups had comparable risk factors. Hemoglobin, urea and creatinin were measured for all patients. There were no statistically significant differences in blood pressure between the two groups at the time of presentation.

	Group I(n = 50)		Group II (n = 10)		
	Mean	±SD	Mean	±SD	P value
RV longitudinal diameter (cm)	5.6	0.8	5	0.7	0.002
RV mid cavity diameter (cm)	2.5	0.6	2.1	0.2	<0.001
RV basal diameter (cm)	3.4	0.6	2.9	0.6	<0.001
RV systolic area (cm2)	18.35	2.91	9.21	2.15	<0.001
RV diastolic area (cm2)	23.08	1.65	15.61	1.29	<0.001
TAPSE (cm)	2.3	0.2	2.5	0.2	<0.001
PASP (mmHg)	51.9	11.9	24.9	2.2	<0.001
FAC (%)	40.8	5.2	47.5	6.3	<0.001
RA longitudinal diameter (cm)	4.6	0.6	3.8	0.6	<0.001
RA transverse diameter (cm)	3.6	0.7	2.9	0.6	<0.001
RA systolic area (cm2)	29.4	13	18.4	1.5	0.002
Tricuspid E wave	42.5	12.8	71.4	9.2	<0.001
Tricuspid A wave	66	14.9	39.9	4.1	<0.001
Tricuspid E/ wave	9.73	1.89	14.19	1.79	<0.001
Tricuspid A/ wave	14.21	2.64	12.09	1.46	<0.001
Tricuspid S wave	10	3.1	12.9	1.5	<0.001
Tricuspid E/A ratio	1.04	0.35	1.51	0.05	<0.001
Tricuspid E\E/ ratio	5.92	2.1	5.11	0.48	0.605
MPI	0.6	0.1	0.5	0.1	0.004
LV EF (%)	66	5.8	67.9	6.7	0.358

Table 3: Echocardiographic parameters (conventional and tissue Doppler): Regarding conventional echocardiographic measures, group I patients had larger right ventricular diameters (longitudinal, mid cavity, and basal) and areas (systolic and diastolic) and right atrial diameters (longitudinal and transverse). When compared to group II patients, RV FAC and TAPSE were significantly lower in group I patients. In group I patients, the tricuspid valve's E wave velocity and the tricuspid E/A ratio were both substantially lower. In group I, the tricuspid valve's A wave velocity was substantially enhanced. The difference between the two groups in LV ejection percentage has not been statistically significant. Regarding Tissue Doppler echocardiographic parameters, The E/ and S velocities of the tricuspid valve were substantially decreased in group I patients. In group I, the tricuspid valve A/ velocity was substantially higher. In comparison to group II, MPI was considerably greater in group I.

	GroupI (n=50)		GroupII (n=10)		
	Mean	±SD	Mean	±SD	P value
RVGLS	-16.87	4.16	-22.54	1.48	<0.001

Table 4: Speckle tracking echocardiographic parameter of RVGLS.

	RV strain	
	R	P value
Age(years)	-0.281	0.005
RV longitudinal diameter(cm)	-0.326	0.001
RV mid cavity diameter(cm)	-0.372	<0.001
RA transverse diameter	-0.24	0.016
Tricuspid E/A ratio	-0.246	0.014
FAC	0.313	0.002
LV EF (%)	0.241	0.016

Table 5: Correlation between RV global longitudinal strain and other parameters. RVGLS was significantly decreased in group I patients. It has been shown to be inversely linked to age, the diameters of the RV (longitudinal diameter, mid-cavity diameter), the RA transverse diameter, and the tricuspid E/A ratio. While it exhibited a significant positive connection with FAC and LV ejection fraction.

DISCUSSION

In hemodialysis patients, right ventricular dysfunction (RVD) is frequent. Furthermore, because to interventricular contact, RV dysfunction may influence LV filling. RVD detection will aid in the identification of patients with a higher CV risk. [13]

As a result, a precise and efficient technique of evaluating RV function was necessary. TAPSE and the right ventricular myocardial performance index were the most often utilized echocardiographic measures in previous RV function investigations**.** While this study used RV speckle tracking to evaluate right ventricular function. [14]

In this study, the differences in systolic and diastolic blood pressure have not been substantial.

This wasn't similar to the study performed by Sun et al., 2018 on the long-term effects of hemodialysis on the RV assessed via 3D speckle tracking echocardiography. They found that patients on maintenance hemodialysis possessed considerably greater systolic and diastolic blood pressure. [15]

The longitudinal, mid cavity, and basal diameters of the right ventricle were substantially enlarged in group I patients (p value 0.001). Additionally, RV areas (systolic and diastolic) were substantially enlarged (p value 0.001) in group I patients. Whereas RV FAC was substantially reduced (p value 0.001) in group I patients.

These results were consistent with Karavelioglu et al., 2015 who assessed RV functions in non-diabetic, normotensive hemodialysis patients. They discovered that ESRD patients had a substantially larger RV end diastolic area than controls. While FAC was substantially lower in patients with ESRD, this was due to decreased RV systolic function. [16]

While Tamulenaite et al., 2018 researchers that examined changes in left and right ventricular mechanics and functions in ESRD patients receiving hemodialysis obtained findings that differed from ours on RV FAC, which had not been observed to be altered by preload decrease. This may be explained by maintaining radial RV distortion in individuals with ESRD while decreased RV longitudinal function (TAPSE, RV S, and RV GLS). [17]

In the current study, patients in group I had significantly higher estimated PASP and RV MPI. In group I patients, TAPSE (tricuspid annular plane systolic excursion) was considerably reduced.

These results were consistent with Karavelioglu et al., 2015 who discovered that ESRD patients had significantly higher mean and systolic pulmonary artery pressures (p values 0.001 and 0.006, respectively). Furthermore, they found that RV MPI was substantially higher in the ESRD group (p =0.007). TAPSE was significantly lower in the ESRD group (p =0.003).[16]

Also, El-Deen et al., 2015 assessed the RV function in hemodialysis patients using tissue Doppler. The researchers discovered a significant rise in RV MPI in hemodialysis patients when compared to the control group. They found that TDI MPI had a higher sensitivity and specificity for assessing RV function in dialysis patients than RV FAC.[18]

In the current study, patients in Group I had significantly larger right atrial diameters than patients in Group II.

These results were consistent with Tamulenaite et al., 2018 They reported that RA volume index was significantly increased in the hemodialysis group (p value -0.012).[17]

In the current study regarding the RV diastolic functions, tricuspid E velocity, E/A ratio and E/ velocity were significantly decreased in group I patients.

This was consistent with Karavelioglu et al., 2015 who reported that tricuspid E velocity, tricuspid E/A ratio and tricuspid E/ velocity were significantly decreased in ESRD group indicating RV diastolic dysfunction. [16]

Similarly, Rudhani et al., 2010 who evaluated the diastolic performance of the left and right ventricles in hemodialysis sufferers, found that the tricuspid E wave velocity and E/A ratio were significantly lower in hemodialysis patients, while the A wave was significantly higher. Tissue Doppler imaging revealed that tricuspid S and E\ velocity were significantly reduced in hemodialysis patients.[19]

This was similar to El-Deen et al., 2015 when hemodialysis patients were compared to controls. The A, IVRT, E/E ratio, IVCT, and lateral TDI MPI values were considerably higher in the hemodialysis group (p0.001). Individuals undergoing hemodialysis had significantly lower E, E/A ratio, and S (p0.001). [18]

In the current study, right ventricular global longitudinal strain (RVGLS %) was considerably decreased in patients of group I compared with group II patients (-16.87 ± 4.16 vs. -22.54 ± 1.48%, P < 0.001). The relationship between peak global RVLS and FAC was strong positive (r = 0.313, P value = 0.002).

These results were consistent with Tamulenaite et al., 2018. They reported that the hemodialysis group patients had significantly lower RVGLS values compared with the controls. [17]

Ali et al., 2016, compared right and left ventricular function in hemodialysis sufferers to newly diagnosed uremic patients with maintained systolic function and found that the hemodialysis group's RV global longitudinal strain was significantly lower (-8.55 vs.-10.86, p value 0.018).[20]

CONCLUSION

Patients on chronic hemodialysis had bigger RV and RA diameters. The RV-FAC and TAPSE were both lower in chronic hemodialysis patients. Patients on chronic hemodialysis had significantly reduced global longitudinal strain in the right ventricle. RVGLS was shown to have a significant negative relationship with age, RV diameters, RA maximum diameter, and tricuspid E/A ratio. While it exhibited a substantial positive association with FAC.

REFERENCES

1. Chen SC, Chang JM, Tsai YC, et al. Ratio of transmitral E-wave velocity to early diastole mitral annulus velocity with cardiovascular and renal outcomes in chronic kidney disease. *Nephron Clinical Practice*. 2013;123(1-2):52-60.
2. Hesselstrand R, Scheja A, Wuttge DM, et al. Enlarged right-sided dimensions and fibrosis of the right ventricular insertion point on cardiovascular magnetic resonance imaging is seen early in patients with pulmonary arterial hypertension associated with connective tissue disease. *Scandinavian journal of rheumatology.* 2011;40(2):133-8.
3. Rudski LG, Lai WW, Afilalo J, et al. Guidelines for the echocardiographic assessment of the right heart in adults: a report from the American Society of Echocardiography: endorsed by the European Association of Echocardiography, a registered branch of the European Society of Cardiology, and the Canadian Society of Echocardiography. *Journal of the American society of echocardiography.* 201;23(7):685-713.
4. Unlu S, Sahinarslan A, Gokalp G, et al. The impact of volume overload on right heart function in end- stage renal disease patients on hemodialysis. *Echocardiography.* 2018;35(3):314-21.
5. Dwivedi G, Mahadevan G, Jimenez D, et al. Reference values for mitral and tricuspid annular dimensions using two-dimensional echocardiography. *Echo research and practice*. 2014;1(2):43-50.
6. William V and El Kilany W. Assessment of right ventricular function by echocardiography in patients with chronic heart failure. *The Egyptian Heart Journal.* 2018;70(3):173-9.
7. Smolarek D, Gruchała M and Sobiczewski W. Echocardiographic evaluation of right ventricular systolic function: The traditional and innovative approach. *Cardiology journal*. 2017;24(5):563-72.
8. Koestenberger M, Apitz C, Abdul-Khaliq H, et al. Transthoracic echocardiography for the evaluation of children and adolescents with suspected or confirmed pulmonary hypertension. Expert consensus statement on the diagnosis and treatment of paediatric pulmonary hypertension. The European Paediatric Pulmonary Vascular Disease Network, endorsed by ISHLT and DGPK. *Heart*. 2016;102:14-22.
9. Zhao X, Teo SK, Zhong L, et al. Reference Ranges for Left Ventricular Curvedness and Curvedness-Based Functional Indices Using Cardiovascular Magnetic Resonance in Healthy Asian Subjects. *Scientific reports.* 2020;10(1):1-7.
10. Mahmoud M, Shalan IM and Azeem HA. Impact of pulmonary hypertension on biventricular functions tissue doppler echocardiographic study. *Egyptian Journal of Chest Diseases and Tuberculosis*. 2017;66(1):137-44.
11. Silverton NA, Lee JP, Morrissey CK, et al. A comparison of left-and right-sided strain software for the assessment of intraoperative right ventricular function. *Journal of cardiothoracic and vascular anesthesia*. 2019;33(6):1507-15.
12. Maffessanti F, Gripari P, Tamborini G, et al. Evaluation of right ventricular systolic function after mitral valve repair: a two-dimensional

Doppler, speckle-tracking, and three-dimensional echocardiographic study. *Journal of the American Society of Echocardiography*. 2012;25(7):701-8.

13. Kırali K, Ozer T and Selcuk E. POST-LVAD right ventricular failure. *InRight Heart Pathology Springer, Cham.* 2018; 807-35.

14. Lemarie J, Huttin O, Girerd N, et al. Usefulness of speckle-tracking imaging for right ventricular assessment after acute myocardial infarction: a magnetic resonance imaging/echocardiographic comparison within the relation between aldosterone and cardiac remodeling after myocardial infarction study. *Journal of the American Society of Echocardiography.* 2015;28(7):818-27.

15. Sun JP, Stewart WJ, Yang XS, et al. Differentiation of hypertrophic cardiomyopathy and cardiac amyloidosis from other causes of ventricular wall thickening by two-dimensional strain imaging echocardiography. *The American journal of cardiology*. 2009;103(3):411-5.

16. Karavelioglu Y, Ozkurt S and Kalcik M. Echocardiographic assessment of right ventricular function in nondiabetic normotensive hemodialysis patients. *Interventional Medicine & Applied Science*. 2015; 7(3):95–101.

17. Tamulėnaitė E, Zvirblyte R, Ereminiene R, et al. Changes of left and right ventricle mechanics and function in patients with end-stage renal disease undergoing haemodialysis. *Medicina*. 2018; 54(5):87.

18. El-deen MB and George SK. Right ventricular functions in hemodialysis patients: tissue doppler study. *Med. J. Cairo Univ*. 2015;83(2):385-91.

19. Rudhani ID, Bajraktari G, Kryziu E, et al. Left and right ventricular diastolic function in hemodialysis patients. *Saudi Journal of Kidney Diseases and Transplantation.* 2010;21(6):1053.

20. Ali HA, Mohamad NA, Mohammad HS, et al. 2-D Speckle tracking in the assessment of left and right ventricular functions in hemodialysis versus recently diagnosed uremic patients with preserved systolic function. *The Egyptian Journal of Critical Care Medicine.* 2016;4(3):139-44.