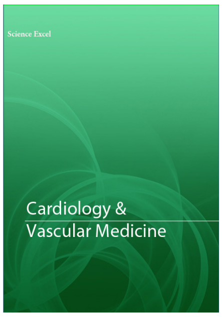
Cardiology and Vascular Medicine

Original Article



Echocardiographic Assessment of Left Ventricular Multidirectional Deformation in Patients of Hypertension and Chronic Renal Failure with Normal Versus Reduced Left Ventricular Ejection Fraction

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Keywords

Hypertension, Global longitudinal strain, Left ventricular mass index, Echocardiography

Abstract

Background: *End-stage renal disease (ESRD) significantly increases cardiovascular (CV) risk, with CV mortality rates 10 to 100 times higher in dialysis patients compared to the general population. Hypertension, a key CV risk factor, contributes to this elevated risk. This study aimed to assess left ventricle (LV) multidirectional deformation in patients of hypertension and chronic renal failure with normal versus reduced LV ejection fraction (LVEF).*

Materials and methods: *This hospital based prospective study was conducted May 2021 to May 2022. Study included 61 patients, aged 18-70 years, with chronic kidney disease (CKD) undergoing dialysis, with good echocardiographic images. Demographic profile (age, gender) of study patients was recorded and they were subjected to trans-thoracic Echocardiography (TTE) evaluation. Data thus collected was subjected to statistical analysis.*

Results: *Majority of patients were in the age group of 40-59 years (44.26%), and 83.61% were male. End Systolic Volume (ESV), End Diastolic Volume (EDV), and LV mass were higher in Reduced LVEF group patients, as compared to Normal LVEF group patients. There was statistically significant correlation of LVEF with both global longitudinal strain (GLS) and global circumferential strain (GCS) ($p<0.001$). Significant difference was observed in A-velocity ($p=0.005$), E/A ratio ($p=0.009$), and deceleration time ($p=0.05$) between the two study groups*

Conclusion: *Myocardial deformation analysis by GLS and GCS are a good method to assess LV function to detect early heart failure in chronic renal failure patients as compared to previous methods.*

Introduction

Chronic kidney disease (CKD) affects about 13% of the U.S. population, with prevalence expected to rise due to an aging population and more cases of diabetes and hypertension [1]. CKD is defined by kidney damage or reduced kidney function, indicated by abnormal albumin excretion or a lowered glomerular filtration rate (GFR) for more than three months. The National Kidney Foundation's Kidney Disease Outcomes Quality Initiative classifies CKD into five stages based on GFR levels [1]. End-stage renal disease (ESRD) significantly increases cardiovascular (CV) risk, with CV mortality rates 10 to 100 times higher in dialysis patients compared to the general population. Hypertension, a key CV risk factor, contributes to this elevated risk. Heart failure (HF) is the most common CV complication in CKD, and its prevalence increases as kidney function declines. CKD and ESRD patients often experience left ventricular (LV) abnormalities, including

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myocardial hypertrophy, which can lead to ischemia, cell death, fibrosis, and diastolic dysfunction [2].

Deformation analysis, which examines ventricular mechanics during the cardiac cycle, includes assessing myocardial strain, strain rate, or torsion. Two-dimensional echocardiography, including Doppler imaging, is essential for evaluating LV structure, function, and HF causes, such as LV hypertrophy, ischemia, valvular disease, and pericardial issues [3,4]. This study was conducted to assess LV multidirectional deformation in patients of hypertension and chronic renal failure with normal versus reduced LV ejection fraction.

Materials and methods

This hospital based prospective study was conducted in the department of Cardiology from May 2021 to May 2022 after obtaining approval from Institutional Ethical Committee. Study included 61 patients, aged 18-70 years, with CKD undergoing dialysis, with good echocardiographic images. Patients with chest deformity, congenital heart disease, valvular heart disease, myocarditis, and those with coronary artery bypass grafting (CABG) were excluded from the study. Written informed consent was obtained from each patient prior to their enrollment in the study. Demographic profile (age, gender) of study patients was recorded in a predesigned and pretested Proforma and they were subjected to echocardiography evaluation using complete trans-thoracic Echocardiography (TTE), and the images required for strain imaging echocardiogram were recorded.

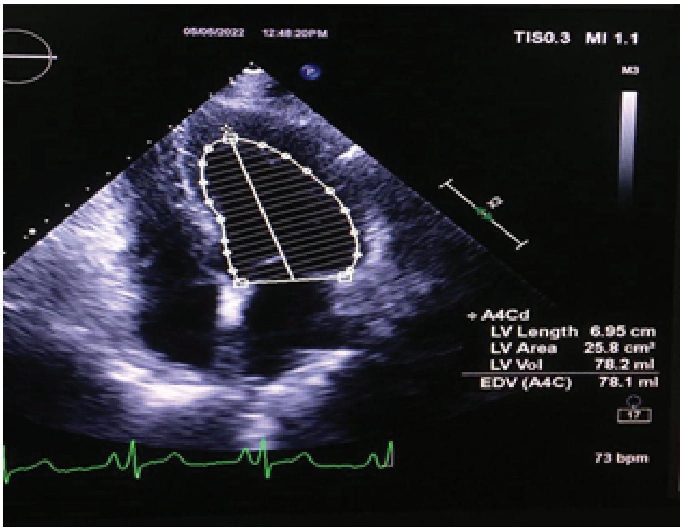

***Figure 1.** Measurement of Ventricular volume through Simpson's rule*

Echocardiography assessment

Simpson's Method or Rule of Disk:

Ventricular volume was measured by recording apical four- and/or two-chamber views, where the endocardial border was outlined at end-diastole and end-systole. The ventricle was then mathematically divided along its long axis into a series of disks of equal height. Each disk's volume was calculated by multiplying its height by its area, and the total ventricular volume was obtained by summing the volumes of all the disks. (Figure 1)

LV Mass

By using Area length method, we have measured the epicardial and endocardial area from short axis view at mid-ventricular level. The ventricular long axis, i.e., length(L) was measured in apical four chamber view. (Figure 2)

AREA - LENGTH FORMULA = LV mass(g) = AREA / LENGTH

Strain Imaging

Speckle Tracking Echocardiography (STE) was performed on patients in the left lateral decubitus position using a standard 2D gray-scale transthoracic acquisition. Images of the LV were captured from apical two, three, and four-chamber views, as well as parasternal short-axis (PSAX) views at the basal, mid, and apical levels, using an EPIQ 7C echo machine with an X5 probe and ECG gating. Offline analysis was conducted with automated software on the EPIQ 7C echo machine. The left ventricular endocardial borders were manually traced on each apical and short-axis view. The software automatically divided the LV circumference into six segments and generated myocardial strain curves for each segment throughout the cardiac cycle. Longitudinal strain was measured from the apical two, three, and four-chamber views, while circumferential strain was obtained from the PSAX at

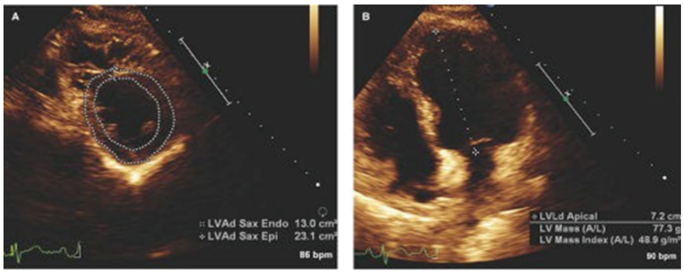

***Figure 2.** Measurement of LV Mass*

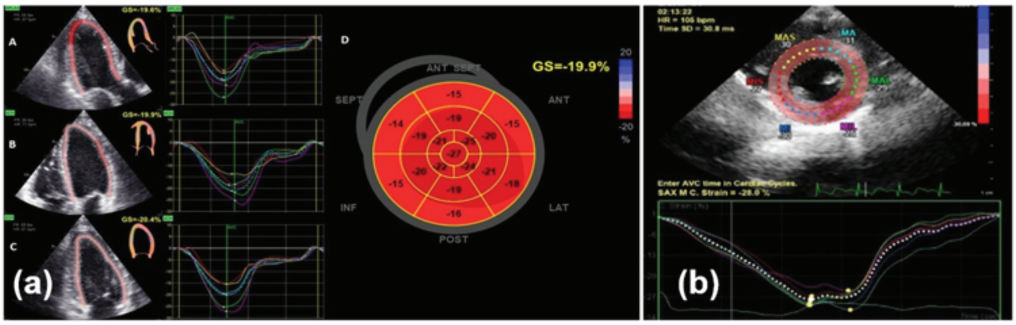

***Figure 3.** Global Strain Evaluation (a) Longitudinal; and (b) Circumferential*

basal, mid, and apical levels. Finally, global strain for both longitudinal and circumferential measures was calculated (Bull's eye). (Figure 3)

Doppler study

Diastolic dysfunction was evaluated by measuring the inflow velocity across the mitral valve between the left atrium (LA) and LV, specifically timing the E wave from its onset to its peak. Mitral inflow was recorded from the apical four-chamber view, with the sample volume positioned at the mitral leaflet tips. An ECG-gated apical four-chamber view was obtained, and pulse-wave (PW) Doppler was applied across the mitral valve. The Doppler recording displayed an E wave and A wave, which were individually measured to calculate the E/A ratio, used to grade diastolic dysfunction. To determine deceleration time (DT), the slope of the early diastolic E wave was traced from the peak inflow velocity to the end of the rapid filling phase. (Figure 4)

Statistical analysis

The data was analyzed by software 20.0. Continuous variables were presented as mean standard deviation (SD) and / or (max and min), and analyzed for normal value by the test named - Fisher's exact test. The comparison of continuous variables is done using sample that is paired t-test for data with normal distribution and if the data were normally not distributed, Wilcox on test was used. Significant p value of less than 0.05 under the test were two tailed.

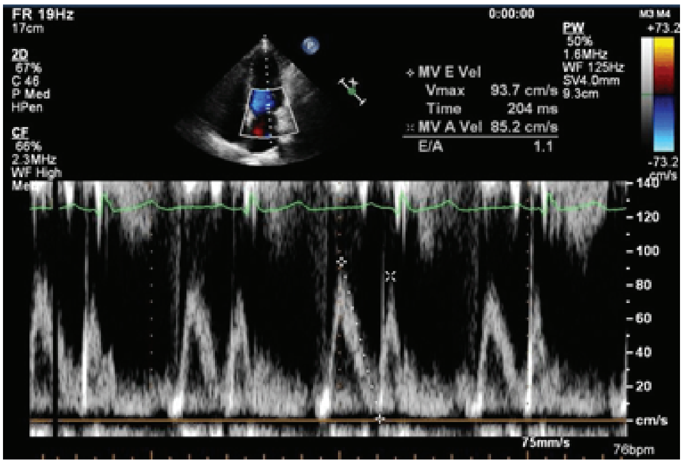

Figure 4. *Doppler Study for measuring Diastolic Dysfunction*

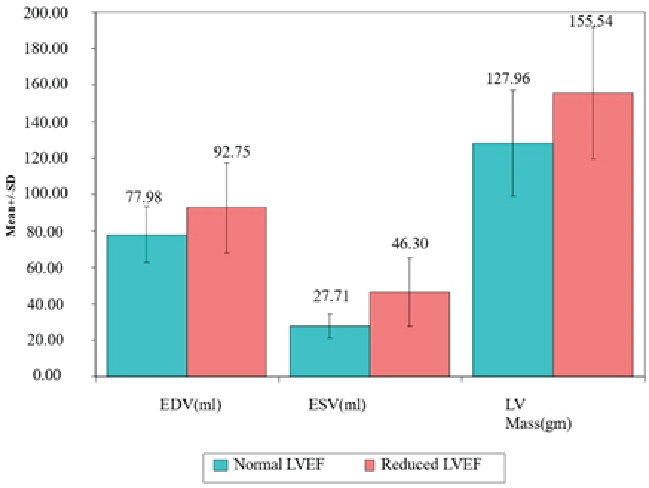

Figure 5. *Comparison of End Diastolic Volume, End Systolic Volume, and LV mass between Normal LVEF and Reduced LVEF group Patients*

Table 1. *Comparison of Age and Gender of Study Patients in Normal LVEF and Reduced LVEF groups*

Profile	Normal LVEF %	Reduced LVEF %	Total %	Chi- square	p-value
Age groups					
20-39yrs	6 (37.50%)	10 (62.50%)	16 (26.23%)	0.6310	0.7290
40-59yrs	13 (48.15%)	14 (51.85%)	27 (44.26%)		
≥60yrs	9 (50.0%)	9 (50.0%)	18 (29.51%)		
Gender					
Male	22 (43.14%)	29 (56.86%)	51 (83.61%)	0.9570	0.3280
Female	6 (60.0%)	4 (40.0%)	10 (16.39%)		

Table 2. *Comparison of Demographic Profile of Study Patients in Normal LVEF and Reduced LVEF groups*

Profile	Normal LVEF Mean±s.d.	Reduced LVEF Mean±s.d.	t-value	p-value
Age	50.79±13.73	49.18±16.16	0.4135	0.6807
Height cm)	165.57±4.52	165.58±4.82	-0.0036	0.9971
Weight(kg)	59.93±10.80	59.82±7.02	0.0480	0.9619
BMI (kg/m²)	21.83±3.66	21.76±1.72	0.1077	0.9146
BSA (m²)	1.65±0.16	1.66±0.13	-0.2076	0.8363

Results

In this study, majority of patients were in the age group of 40-59 years (44.26%), and 83.61% were male. Both the Normal LVEF and Reduced LVEF groups patient were comparable in terms of demographic profile. (Table 1 and 2) The End Systolic Volume (ESV) was significantly higher in Reduced LVEF group patients, as compared to Normal LVEF group patients (p=0.0001). The End Diastolic Volume (EDV) and the Left ventricular mass were higher in Reduced LVEF group patients than Normal LVEF group patients, but it was not statistically significant (p>0.05). (Figure 5) Comparison of Strain between the two study groups by Karl Pearson's correlation coefficient showed that there was statistically significant correlation of LVEF with both GLS and GCS, also there was significant association between GLS and GCS in this study. (Table 3) Significant difference was observed in A-velocity (p=0.005), and E/A ratio (0.009) between the two study groups. (Figure 6) Comparison of DT, E/Medial E', and E/Lateral E' between the two study groups showed that there was significant difference in DT (p=0.05), and E/Medial E' (p=0.001) between patients in Normal LVEF group and Reduced LVEF group. (Figure 7).

Table 3. *Correlation of LVEF (%) with GLS (%) and GCS (%) between Normal LVEF and Reduced LVEF group Patients*

Correlation between	r-value	t-value	p-value
LVEF (%) and GLS (%)	-0.7806	-9.5944	0.0001*
LVEF (%) and GCS (%)	-0.6286	-6.2088	0.0001*
GLS (%) and GCS (%)	0.6012	5.7782	0.0001*

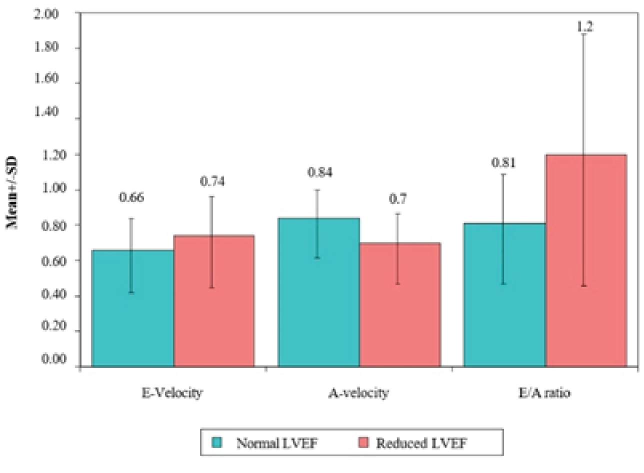

Figure 6. *Comparison of E-velocity, A-velocity, and E/A ratio between Normal LVEF and Reduced LVEF group Patients*

Discussion

In our study, left ventricular function in CKD patients on dialysis was assessed using strain imaging, alongside measurements of EDV, ESV, LVEF, and LV mass. We conducted a multivariable analysis that included age, height, weight, and body surface area (BSA). The majority of the study participants were male (83.61%), with the remaining being female. Similarly, one recent study found a higher proportion of male patients compared to females, suggesting a higher prevalence of CKD among males.[5] Our study also indicated that hypertensive patients are at greater risk.

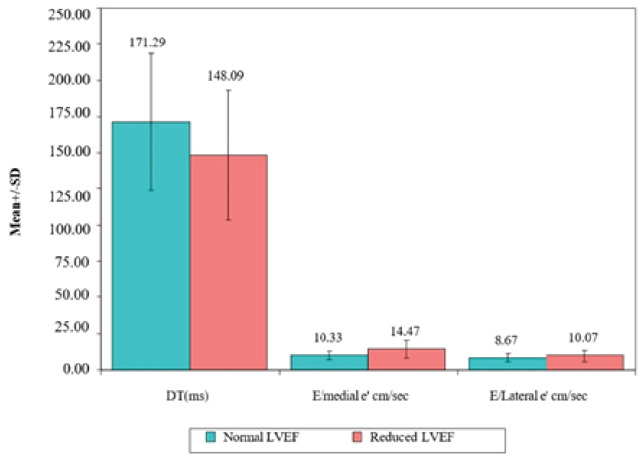

Figure 7. *Comparison of DT, E/Medial E', and E/Lateral E' between patients in Normal LVEF group and Reduced LVEF group*

In patients with normal LVEF, the end-diastolic volume was 77.98±15.48, while in those with reduced LVEF, it was 92.75±24.81, with a statistically significant p-value of 0.0083. Chronic hypertension and vascular stiffness lead to pressure overload, and CKD is linked to functional and structural LV remodeling due to volume overload, pressure, and non-hemodynamic factors. The ESV in normal LVEF patients was 27.71±6.59, compared to 46.30±18.82 in those with reduced LVEF, with a highly significant p-value of 0.0001. LV mass in normal LVEF patients was 127.96±28.93, whereas in reduced LVEF patients, it was 155.54±36.18, with a significant p-value of 0.0019.

Strain imaging results showed that the GLS in normal LVEF patients was -23.05±2.96, while in reduced LVEF patients, it was -17.41±4.36, with a p-value of 0.0001, indicating statistical significance. The GCS in normal LVEF patients was -31.00±8.83, compared to -21.39±7.98 in those with reduced LVEF, also with a significant p-value of 0.0001.

Doppler evaluation revealed that the DT in normal LVEF patients was 171.29±47.05, while in reduced LVEF patients, it was 148.09±44.80, with a p-value of 0.0500. The mitral E wave velocity was 0.66±0.21 in normal LVEF patients and 0.74±0.26 in reduced LVEF patients, with a p-value of 0.2473, which was not statistically significant. The mitral A wave velocity in normal LVEF patients was 0.84±0.19, whereas in reduced LVEF patients, it was 0.70±0.20, with a statistically significant p-value of 0.0052. The mitral E/A ratio was 0.81±0.31 in normal LVEF patients and 1.20±0.71 in reduced LVEF patients, with a significant p-value of 0.0094.

Conclusion

We determined that the myocardial deformation method is a reliable predictor for assessing left ventricular function in patients with chronic renal failure, enabling the early detection of HF more effectively than previous methods. In patients with normal LVEF, the GLS was -23.05±2.96, while in those with reduced LVEF, it was -17.41±4.36, showing a significant p-value of 0.0001. Similarly, the GCS in patients with normal LVEF was -31.00±8.83, compared to -21.39±7.98 in those with reduced LVEF, also with a significant p-value of 0.0001.".

References

1. Schrier RW. Diseases of the Kidney & Urinary Tract. 8th ed. Philadelphia: Lippincott Williams & Wilkins; 2007.
2. Ali HAR, Mohamad NAR, Mohammad HSED, Abdul Hamid SKA. 2-D speckle tracking in the assessment of left and right ventricular functions in hemodialysis versus recently diagnosed uremic patients with preserved systolic function. Egypt J Crit Care Med. 2016;4(3):139-144. doi:10.1016/j.ejccm.2016.08.001.
3. van Dalen BM, Kauer F, Soliman OI, Vletter WB, Michels M, ten Cate FJ, et al. Influence of the pattern of hypertrophy on left ventricular twist in hypertrophic cardiomyopathy. Heart. 2009;95(8):657-661. doi:10.1136/hrt.2008.152777.
4. Marwick TH. Measurement of strain and strain rate by echocardiography: ready for prime time? J Am Coll Cardiol. 2006;47(7):1313-1327. doi:10.1016/j.jacc.2005.11.063.
5. Loutradis C, Pickup L, Law JP, Dasgupta I, Townend JN, Cockwell P, et al. Acute kidney injury is more common in men than women after accounting for socioeconomic status, ethnicity, alcohol intake and smoking history. Biol Sex Differ. 2021;12(1):30. doi:10.1186/s13293-021-00373-4.