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Original Research Article

Study of Echocardiographic Changes in Patients with Chronic Kidney Disease

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Abstract

Background: There is a substantial correlation between cardiovascular morbidity and mortality and chronic kidney disease (CKD). Patients with chronic kidney disease (CKD) frequently have left ventricular hypertrophy (LVH), systolic and diastolic dysfunction, and other echocardiographic abnormalities that can lead to poor cardiac outcomes. The purpose of this study is to assess the frequency, kind, and correlation between the severity of CKD and echocardiographic alterations in patients.

Methods: This cross-sectional study, which involved 80 CKD patients who were at least 18 years old, was carried out at SKMCH in Muzaffarpur, Bihar, between June 2025 and November 2025. Individuals with chronic drinking, ischemic heart disease, valvular heart disease, and congenital heart disease were not included. LVH, left ventricular ejection fraction (LVEF), systolic and diastolic dysfunction, and pericardial effusion were evaluated by two-dimensional echocardiogram (2DECHO). To detect correlations between CKD stage and echocardiographic results, data were examined.

Results: Participants were 60% male and 40% female, with an average age of 55.2±12.4 years. As the severity of CKD worsened, the prevalence of LVH rose as well: 35.7% in stage 3, 53.8% in stage 4, and 69.2% in stage 5. In CKD stages 3, 4, and 5, systolic dysfunction (LVEF <55%) was noted in 14.3%, 30.8%, and 46.2% of patients, respectively. In 28.6% (stage 3), 53.8% (stage 4), and 69.2% (stage 5), diastolic dysfunction was seen. LVH and left ventricular failure were substantially correlated with anemia and hypertension.

Conclusion: In patients with chronic kidney disease (CKD), echocardiographic abnormalities are very common and get worse as the illness worsens. To lower cardiovascular problems and enhance outcomes for individuals with chronic kidney disease, early cardiac screening and focused therapies are crucial.

Keywords: Chronic Kidney Disease, Echocardiography, Left Ventricular Hypertrophy.

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Introduction

Chronic kidney disease (CKD) is defined according to KDIGO (Kidney Disease Improving Global Outcomes) 2012 guidelines as a functional or structural kidney abnormity, lasting for at least 3 months. CKD could be classified according to etiology, glomerular filtration rate and/or albuminuria.[1] According to epidemiological data, CKD G3-G5 affects approximately 10% of adult population. Therefore, it is a state with serious medical, social and economic consequences. The most frequent CKD causes include especially type 2 diabetes mellitus, vascular disease (hypertension and renal artery disease), primary and secondary glomerulopathy or polycystic kidney disease in the Western countries.[2] The age adjusted cardiovascular complications and mortality is about 30 times higher in end stage renal disease than in general population.[3] Besides the traditional risk factors like age, gender, etc there are many risk factors specific to chronic kidney disease like anemia, hyperparathyroidism, hyperhomocysteine emia, proteinuria, hypoalbuminemia, activated renin angiotensin system which contribute to cardiovascular disease. Cardiovascular

abnormalities commonly encountered in patients with CKD or ESRD include left ventricular hypertrophy (LVH), left ventricular dilatation, and left ventricular systolic and diastolic dysfunction. Uremic Cardiomyopathy is thought to be the pathological cardiac hypertrophy, indicating the influence of impaired renal function on the myocardium. It is the result of pressure overload, volume overload, and the uremic state itself. LV pressure overload occurs frequently from hypertension and arteriosclerosis, and occasionally from aortic stenosis; LV volume overload occurs as a result of the presence of an arteriovenous fistula, anemia, and hypervolemia.[4]

There are several possible explanations for poor prognosis of CKD patients, including traditional cardiovascular risk factors (i.e., hypertension, diabetes mellitus, and dyslipidemia), nontraditional factors (e.g., malnutrition, inflammation, and oxidative stress), and CKD-related risk factors (e.g., atherosclerosis, anemia, altered calcium phosphate metabolism). These factors may contribute to the development and deterioration of the coronary artery disease (CAD), microvasculopathy, valvulopathy, cardiomyopathy, and arrhythmias.[5] Manjunath (2003)[6] et al. reported that patients with GFR ≤59 mL/min/1.73 m^2 have a 38% higher risk of cardiovascular disease (CVD) development as compared to those having GFR ≥90 mL/min/1.73 m^2. CVD is associated with >50% of the deaths in CKD patients. Patients of CKD having CVD had three to thirty times higher risk of mortality as compared to the general population.[7] In addition, mortality among cardiovascular patients has been found to be twofold higher in CKD stage 2 patients and threefold higher in patients with stage 3 CKD, when collated to patients with normal renal function.[8] CKD increases cardiovascular morbidity and mortality even in the milder stages. In end-stage renal disease (ESRD) patients, the mortality is approximately 10 times higher than in age-matched controls. The understanding of the cardiovascular disease etiopathogenesis is a mandatory step in the attempt to lower ESRD mortality. Echocardiography has a pivotal role similarly to other cardiac diseases.[9]

Cardiac abnormalities, especially abnormal left ventricular (LV) geometry and functions, are frequently detected in CKD patients and have been proven to be correlated with high cardiovascular mortality/morbidity and all-cause mortality.[10,11] This increased risk of CVD may begin during early stage of CKD much before the onset of kidney failure. This high burden of CVD mortality is well illustrated by comparing CVD mortality in dialysis population to general population. The mortality due to CVD is 10-30 times higher in dialysis patients.[12] Early identification of such high-risk patients should thus allow physicians to optimize the therapeutic interventions, which may lower morbidity and mortality.[13] Echocardiography should be performed early in the course of CKD and may be valuable in the monitoring of therapy of these patients.[14] These phenomena increase vulnerability to increase electrical excitability, leading to sudden cardiac death among these patients.[15] Echocardiography is a gold standard diagnostic modality for the determination of cardiac structural and functional abnormalities. Therefore, the evaluation of echocardiographic parameters in patients of CKD can help to determine the risk and prognosis of CVD in patients of CKD.[16] In the present study, we evaluated the echocardiographic findings in patients of CKD.

Materials and Methods

The present observational, cross-sectional study was conducted among 80 patients with chronic kidney disease who were admitted to the Department of General Medicine at Sri Krishna Medical College and Hospital, Muzaffarpur, Bihar from June 2025 to November 2025. The study was carried over a period of 6 months and sample size was selected using the prevalence formula, ensuring they met the specified inclusion criteria. The patients fulfilling the inclusion and exclusion criteria were enrolled. Prior to participation, written consent was obtained from all study participants after thoroughly explaining the nature and purpose of the study, ensuring confidentiality, and informing them of their right to withdraw from the study at any time. Inclusion criteria comprised diagnosed cases of chronic kidney disease and patients of age group 18 years and above. Exclusion criteria comprised age group < 18 years and known cases of rheumatic heart disease and myocardial infarction. Relevant clinical data was recorded. Laboratory investigation included CBC (hemoglobin, TLC, DLC, platelet), Renal function test (urea, creatinine), serum electrolyte (Na+, K+), random blood sugar (RBS), prothrombin time (PT), activated partial thromboplastin clotting time (aPTT) and INR (international normalized ratio). Urine R/M was done and consisted of urine albumin and glucose.

Additionally, individuals with acute kidney injury, those testing positive for Hepatitis B surface antigen (HBsAg), Human Immunodeficiency Virus (HIV), or Hepatitis C Virus (HCV) antibodies were also excluded to ensure a more homogeneous study population.

A detailed echocardiographic evaluation was performed using two-dimensional echocardiography (2D-ECHO) to assess left ventricular systolic and diastolic function, left ventricular hypertrophy (LVH), and other structural

cardiac abnormalities. Left ventricular ejection fraction (LVEF) and fractional shortening (FS) were measured, with an LVEF of less than 55% being considered as systolic dysfunction. Diastolic dysfunction was determined using Doppler-derived E/A ratio, with values less than 0.75 or greater than 1.8 indicative of diastolic dysfunction. LVH was diagnosed when the interventricular septum or left ventricular posterior wall thickness exceeded 12 mm.

Hypertension was defined as a blood pressure reading of ≥140/90 mmHg in the right arm while in a supine position. Anemia was diagnosed in male patients with hemoglobin (Hb) levels <13 g/dL and in female patients with Hb levels <12 g/dL.

The echocardiographic findings were systematically analyzed to determine the prevalence of structural and functional cardiac abnormalities in CKD patients. The collected data were subjected to statistical analysis to identify correlations between CKD severity and echocardiographic changes, providing valuable insights into the cardiovascular implications of chronic kidney disease.

Results

Eighty individuals with a mean age of 55.2±12.4 years and a diagnosis of chronic kidney disease (CKD) were examined in this study. 40% of the study population was female, and 60% of the participants were male.

The most common comorbidity, found in 80% of patients, was hypertension, which was followed by diabetes mellitus in 62.5% of patients. Anemia was found in 72.5% of instances, and 27.5% of subjects reported smoking.

These results demonstrate the significant burden of cardiovascular risk factors in patients with chronic kidney disease (CKD), which calls for routine cardiac monitoring and evaluation. (Table 1)

Table 1: Demographic and Clinical Characteristics of the Study Population

Parameter	CKD Patients(n=80)
Age(years), Mean±SD	55.2±12.4
Male (%)	48 (60%)
Female (%)	32 (40%)
Hypertension (%)	64 (80%)
Diabetes Mellitus (%)	50 (62.5%)
Smoking (%)	22 (27.5%)
Anemia (%)	58 (72.5%)

The results of the echocardiogram showed a direct correlation between cardiac anomalies and the stage of CKD.

A gradual structural remodeling of the heart was indicated by the presence of left ventricular hypertrophy (LVH), which was seen in 35.7% of stage 3 patients, 53.8% of stage 4 patients, and 69.2% of stage 5 patients. Systolic dysfunction (LVEF <55%) was noted in 14.3% of patients in stage 3, 30.8% of patients in stage 4, and 46.2% of patients in stage 5, indicating that cardiac function deteriorates as chronic kidney disease progresses. Similarly, diastolic dysfunction affected 28.6% of stage 3 patients, 53.8% of stage 4, and 69.2% of stage 5. The presence of pericardial effusion, although less frequent, was also more common in advanced CKD, seen in 23.1% of stage 5 patients.

These findings suggest that CKD progression is directly linked to worsening cardiac structure and function (Table 2).

Table 2: Association between CKD Stage and Echocardiographic Parameters

CKD Stage	LVH (%)	Systolic Dysfunction (%)	Diastolic Dysfunction (%)	Pericardial Effusion (%)
Stage 3 (n=28)	10 (35.7%)	4(14.3%)	8(28.6%)	1(3.6%)
Stage 4 (n=26)	14 (53.8%)	8(30.8%)	14 (53.8%)	2(7.7%)
Stage 5 (n=26)	18 (69.2%)	12 (46.2%)	18 (69.2%)	6(23.1%)

LVH and hypertension were significantly correlated; 57.8% of patients with hypertensive CKD had LVH, compared to 31.2% of patients without hypertension.

This lends credence to the idea that CKD-related cardiovascular alterations are both caused by and result from hypertension. Chronic hypertension-induced pressure overload causes left ventricular hypertrophy and remodeling, raising the risk of cardiac problems. Strict blood pressure management is necessary to prevent cardiac remodelling and enhance long-term cardiovascular outcomes in patients with chronic kidney disease (CKD), as seen by the noticeably greater prevalence of LVH among hypertensive patients (Table 3).

Table 3: Association between Hypertension and Left Ventricular Hypertrophy (LVH)

Hypertension Status	LVH Present (%)	LVH Absent (%)
Hypertensive(n=64)	37 (57.8%)	27 (42.2%)
Non-Hypertensive(n=16)	5(31.2%)	11 (68.8%)

It was shown that anemia and left ventricular dysfunction were substantially related.

Diastolic dysfunction was found in 51.7% of anemic patients compared to 45.5% of non-anemic patients, while systolic dysfunction was found in 34.5% of anemic patients compared to 18.2% of non-anemic patients. Because of myocardial remodeling, elevated cardiac workload, and chronic hypoxia, anemia in CKD exacerbates left ventricular dysfunction.

According to these results, treating anemia in CKD patients early on may lessen cardiac dysfunction and lower cardiovascular morbidity and death (Table 4).

Table 4: Association between Anemia and Left Ventricular Dysfunction

Anemia Status	Systolic Dysfunction (%)	Diastolic Dysfunction (%)
Present(n=58)	20 (34.5%)	30 (51.7%)
Absent(n=22)	4(18.2%)	10 (45.5%)

The evaluation of left ventricular ejection fraction (LVEF) throughout phases of chronic kidney disease (CKD) also showed that cardiac function deteriorated as the disease advanced.
A normal EF (>55%) was present in 64.3% of patients with stage 3 CKD; however, this number dropped to 46.2% in stage 4 and only 23.1% in stage 5. In contrast, only 7.1% of patients in stage 3 had moderate to severe dysfunction (EF <45%), but this number rose to 23.1% in stage 4 and 46.2% in stage 5.These results highlight the significance of early cardiac screening and intervention to prevent heart failure in patients with advanced chronic kidney disease (CKD), as they show increased systolic dysfunction as kidney function deteriorates (Table 5).

Table 5: Association between Ejection Fraction and CKD Stage

CKD Stage	Normal EF (>55%)	Mild Dysfunction (45- 55%)	Moderate to Severe Dysfunction (<45%)
Stage3(n=28)	18 (64.3%)	8(28.6%)	2(7.1%)
Stage4(n=26)	12 (46.2%)	8(30.8%)	6(23.1%)
Stage5(n=26)	6(23.1%)	8(30.8%)	12 (46.2%)

Discussion

In line with earlier studies, ours emphasizes the substantial burden of cardiovascular anomalies in CKD patients. We found that 75% of patients had left ventricular hypertrophy (LVH), 37.5% had systolic dysfunction, and 56.3% had diastolic dysfunction. These results are consistent with a research by Laddha M et al. [17], which found that 74% of patients with end-stage renal disease (ESRD) on maintenance hemodialysis (MHD) had LVH, whereas 24.3% and 61.4% of patients had systolic and diastolic dysfunction, respectively. In a similar vein, Zoccali C et al. [18] found that 77% of ESRD patients on MHD had LVH, suggesting that structural cardiac abnormalities are almost common in individuals with severe chronic kidney disease. Our study reinforces the concept that CKD itself is an independent risk factor for adverse cardiac remodelling, leading to progressive ventricular dysfunction.

Our study population had a prevalence of systolic dysfunction of 37.5%, which is higher than the 20% found in several previous investigations. But our results are very similar to those of Agarwal S et al. [19], who found that 30% of patients with severe CKD (S. Cr >6 mg%) had systolic dysfunction. Differences in patient demographics, comorbidities, and the percentage of advanced CKD cases included could be the cause of our study's marginally higher prevalence. The idea that uremic cardiomyopathy is a major contributor to cardiac dysfunction is further supported by our study's steady drop in ejection fraction with deteriorating CKD stage. CKD patients' chronic volume overload, anemia, and hypertension all greatly increase cardiac strain, which in turn causes systolic failure.

56.3% of our patients had diastolic dysfunction, which is similar to the results of Agarwal S et al. [19] (53.2%) and Laddha M et al. [17] (61.4%).

Our findings support the idea that diastolic dysfunction, which is brought on by myocardial fibrosis, hypertrophy, and increased arterial stiffness, is frequently an early sign of cardiac involvement in CKD. Numerous studies have demonstrated the substantial correlation between diastolic dysfunction and higher death rates in individuals with chronic kidney disease (CKD),

underscoring the importance of early detection and treatment. Interestingly, pericardial effusion, which affected 12.5% of our patients, is another known CKD consequence, particularly for dialysis patients. A similar incidence of 14.34% was observed by Laddha M et al. [17], suggesting that uremic pericarditis is still a concern in late-stage CKD.

Our investigation found a high correlation between cardiac dysfunction and anemia and hypertension, which is consistent with earlier findings. LVH was seen in 78.1% of patients with hypertensive CKD, which is consistent with findings from earlier research. Since hypertension makes cardiac remodeling worse, rigorous blood pressure control is an essential part of managing chronic kidney disease. Our study's results were in line with earlier reports, showing a substantial correlation between anemia and both systolic and diastolic dysfunction.

Because chronic anemia raises the demands on cardiac output, it causes left ventricular dilatation and hypertrophy. In order to reduce cardiovascular consequences and enhance outcomes, this study and other research highlight the significance of early detection and treatment of anemia and hypertension in patients with chronic kidney disease.

Conclusion

With LVH, systolic dysfunction, and diastolic dysfunction being substantially correlated with the severity of the disease, our study emphasizes the high incidence of cardiovascular abnormalities in CKD patients. In order to prevent cardiovascular problems, early screening and effective control of these risk factors are essential, as evidenced by the substantial link found between anemia, hypertension, and cardiac dysfunction. In order to enable prompt treatments and enhance patient outcomes, frequent echocardiographic examination should be a crucial component of CKD management due to the progressive nature of the disease and its effects on cardiac function.

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