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Original Research Article

CROSS-SECTIONAL STUDY FOR ASSESSMENT OF CARDIAC DYSFUNCTION BY 2D-ECHOCARDIOGRAPHY IN PATIENTS OF CHRONIC KIDNEY DISEASE

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ABSTRACT

Background: Chronic kidney disease (CKD) is increasingly associated with cardiovascular morbidity and mortality. Understanding the electrocardiographic (ECG) and echocardiographic alterations in CKD patients, particularly in the context of comorbidities like diabetes mellitus and hypertension, is vital for early cardiac risk stratification.

Materials and Methods: A cross-sectional observational study was conducted on 100 CKD patients to assess cardiac abnormalities using ECG and echocardiography. Demographic data, comorbidities, etiology of CKD, and cardiovascular parameters were analyzed using appropriate statistical tests.

Results: The most common cause of CKD was diabetic nephropathy (34%), followed by chronic glomerulonephritis (24%) and hypertension-associated CKD (18%). ECG abnormalities included left ventricular hypertrophy (59%), ST-T segment changes (22%), and low voltage complexes or electrical alternans (19%) ($p = 0.001$). Echocardiographic findings revealed left ventricular hypertrophy in 59% ($p = 0.001$), systolic dysfunction in 22%—mild (12%), moderate (6%), severe (4%)—and diastolic dysfunction in 25% ($p = 0.033$). Pericardial effusion was seen in 19%, global hypokinesia in 18%, and valvular heart disease in 17%. LVH and systolic dysfunction were significantly more frequent in patients with diabetes and hypertension combined ($p < 0.05$), highlighting the synergistic impact of these comorbidities.

Conclusion: Cardiac structural and functional abnormalities are highly prevalent in CKD patients, particularly those with diabetes and hypertension. Routine echocardiographic and ECG screening is essential in this high-risk population to enable early intervention and reduce cardiovascular complications.

Keywords: Chronic kidney disease left ventricular hypertrophy, systolic dysfunction, diastolic dysfunction, ECG abnormalities, diabetes, hypertension, pericardial effusion, echocardiography, cardiovascular risk.

INTRODUCTION

Chronic kidney disease (CKD) is a prevalent health issue globally. A substantial percentage of the global adult population is predicted to have chronic kidney disease (CKD).[1] In 2021 approx. 673.7 million people worldwide are living with CKD, the estimated global prevalence of CKD Stages 1 was 3.5%, Stage 2 was 2.39%, Stage 3 was 7.6%, Stage 4 was .4%, Stage 5 was 0.11%, dialysis was 0.041%, and kidney transplantation was 0.011%. Cardiovascular disease is regarded as the primary cause of morbidity and mortality in persons with chronic kidney disease (CKD). Heart failure,

coronary artery disease, and cardiac arrhythmias are prevalent in people with chronic kidney disease.[2]

Individuals with chronic kidney disease (CKD) experience a significant burden of cardiovascular disease. KDIGO (Kidney Disease Improving Global Outcomes) defined chronic kidney disease in its 2012 guidelines as any functional or structural renal abnormalities persisting for three months or longer. The estimated global prevalence of chronic kidney disease (CKD) is 13.4% (ranging from 11.7% to 15.1%), with the number of patients requiring renal replacement treatment for end-stage disease estimated between 4.902 million and 7.083 million. The incidence of chronic renal disease in India is 15-17%.[3]

Chronic kidney disease elevates cardiovascular morbidity and death, especially in its less severe phases. In individuals with end-stage renal disease (ESRD), mortality is roughly tenfold more than in age-matched controls. Cardiovascular disorders constitute nearly 50% of fatalities. Comprehending the etiopathogenesis of cardiovascular disease is essential for reducing ESRD mortality. Echocardiography plays a crucial function, akin to other cardiovascular conditions.[4] Left ventricular hypertrophy (LVH) is a significant structural cardiac abnormality in individuals with chronic kidney disease (CKD), linked to an elevated risk of cardiac ischaemia, congestive heart failure, and serves as a robust independent predictor of cardiovascular death. Left ventricular hypertrophy (LVH) is the predominant geometric abnormality in chronic kidney disease (CKD) and serves as an independent prognostic indicator, particularly in individuals undergoing dialysis. Left ventricular systolic dysfunction is a significant predictor of poor prognosis in individuals undergoing haemodialysis. Diastolic dysfunction is defined by changes in ventricular relaxation and compliance, sometimes accompanied by a compensatory rise in filling pressure in later stages. It is closely linked to heart failure and serves as an independent predictor of cardiovascular mortality.[5,6]

Diagnosing heart failure in individuals with end-stage renal disease (ESRD) is challenging, as the symptoms of heart failure are sometimes indistinguishable from those of pure hyperhydration. Echocardiography contributes to the accurate assessment of dry weight, particularly through the measurement of the inferior vena cava's diameter and collapsibility. Additional indicators of increased central venous pressure encompass right atrial dilation, a leftward deviation of the atrial septum, a tricuspid valve E/e′ ratio exceeding 6, and a preponderance of systolic flow in the superior vena cava and/or hepatic veins. Echocardiographic abnormalities are prevalent in patients with end-stage renal disease (ESRD), exhibiting a broad range of irregularities. To avert mortality, regular echocardiographic assessments for the early detection of cardiac problems and the commencement of treatment are essential. The heart and kidneys are intrinsically connected through haemodynamic and regulatory activities.[7] The interaction between the two organs occurs at various levels, including the renin-angiotensin-aldosterone system (RAAS), sympathetic nervous system, antidiuretic hormone, endothelin, and natriuretic peptides. Chronic kidney disease (CKD) encompasses a broad range of pathologies, from initial, subclinical alterations in renal function in individuals with various co-morbidities to end-stage renal disease (ESRD), necessitating renal replacement therapy for survival. Chronic kidney disease (CKD) is acknowledged as an independent risk factor for cardiovascular disease, irrespective of other traditional cardiovascular risk factors. Individuals with early chronic kidney disease (CKD) are at a higher risk of mortality from cardiovascular (CV) illness than of advancing to end-stage renal disease (ESRD). Individuals with end-stage renal disease (ESRD) face a significantly elevated risk of cardiovascular disease compared to the general population. Premature cardiovascular disease is a major contributor to morbidity and mortality in persons with chronic kidney disease (CKD).[8,9] This study aimed to assess cardiac dysfunction in patients with chronic kidney disease and to investigate the significance of 2D echocardiography in diagnosing cardiac complications associated with chronic kidney disease.

MATERIALS AND METHODS

This cross-sectional observational study titled "Assessment of Cardiac Dysfunction by 2D-Echocardiography in Patients with Chronic Kidney Disease" was conducted at the Departments of Medicine and Nephrology, MathuradasMathur Hospital attached to Dr. S. N. Medical College, Jodhpur, after obtaining approval from the Institutional Ethics Committee and the Board of Studies. The study duration was from January 1, 2025, to June 30, 2025. A total of 100 patients were included using a simple random sampling technique.

The sample size was calculated using the standard formula: $N = Z^2 \times P(100-P)/\varepsilon^2$, where P was the expected proportion of cardiac dysfunction among CKD patients (assumed as 56% based on previous studies), Z was the standard normal deviate at 95% confidence level (1.96), and ε was the absolute allowable error, taken as 20% of 56 (i.e., 11.2). The calculation yielded a sample size of 75.46, which was rounded off to 100 for adequate power.

Patients aged ≥18 years of either sex with a confirmed diagnosis of chronic kidney disease (any stage) and those on maintenance hemodialysis were included in the study. Exclusion criteria were: patients with known congenital heart disease, primary cardiomyopathies, valvular heart diseases, ischemic heart disease or prior myocardial

infarction, and those with a diagnosis of hypertension predating the onset of CKD.

After obtaining written informed consent, detailed clinical histories were taken for all participants. This was followed by thorough clinical examination with emphasis on cardiovascular assessment. Laboratory investigations included complete blood count (CBC), renal function tests (RFT), liver function tests (LFT), serum electrolytes, lipid profile, and blood glucose (random and, if needed, fasting/postprandial). All patients underwent abdominal ultrasonography to assess kidney size, echotexture, and any evidence of obstructive uropathy. For cardiac evaluation, standard 12-lead electrocardiography (ECG) and 2D-transthoracic echocardiography (TTE) were performed, and findings were documented using a pre-structured proforma.

The statistical analysis was conducted using the statistical software SPSS version 25.0, after importing the data into a Microsoft Excel spreadsheet. Numerical data was displayed using the mean and standard deviation, while categorical data was shown using the frequency and percentage of each category.The mean values of the two groups were compared using the student t-test, while the chi-square test was used to analyse the frequency differences between the two groups. A p-value below 0.05 indicates statistical significance.

RESULTS

A total of 100 patients diagnosed with chronic kidney disease (CKD), aged 18 years and above, were included in this cross-sectional study conducted at the Department of Medicine and Department of Nephrology, MathuradasMathur Hospital, Jodhpur. Both male and female patients, including those on maintenance dialysis, were enrolled. After obtaining informed consent, all patients underwent a detailed clinical assessment followed by laboratory investigations including complete blood count, renal function tests, serum electrolytes, liver function tests, blood glucose levels, and lipid profiles. For cardiac evaluation, all patients underwent ECG and 2D-echocardiography. ECG revealed abnormalities such as arrhythmias, left ventricular hypertrophy, and ischemic changes in several patients. 2D-echocardiographic assessment provided further insights into cardiac structure and function, highlighting the prevalence of cardiac dysfunction in this population.

Table 1: Demographic and Clinical Profile of Study Participants (N = 100)

Variable	Category / Value	Frequency (n)	Percentage (%)	P-Value
Age (Mean ± SD)	50.5 ± 7.8 years	–	–	–
Gender	Male	64	64%	0.452
	Female	36	36%	
Clinical Symptoms	Pedal edema	12	12%	<0.0001
	Dyspnoea	10	10%	
	Chest pain	36	36%	
	Palpitation	24	24%	
	Vomiting	18	18%	
Hemoglobin Level	Hb< 10 gm/dL	61	61%	–
	Hb ≥ 10 gm/dL	39	39%	
Comorbidities	Diabetes	36	36%	0.012
	Hypertension	38	38%	
	Both DM and HTN	24	24%	
	None	2	2%	

The study population comprised 100 patients with chronic kidney disease (CKD). The mean age of the participants was 50.5 ± 7.8 years, indicating a predominance of middle-aged adults affected by CKD. Males formed the majority of the study group, accounting for 64%, while females constituted 36%, with no statistically significant gender difference (p = 0.452). In terms of clinical presentation, chest pain (36%) was the most frequently reported symptom, followed by palpitations (24%), vomiting (18%), pedal edema (12%), and dyspnoea (10%). The presence of pedal edema showed significant association with CKD (p < 0.0001), possibly reflecting volume overload or cardiac dysfunction. Evaluation of anemia status showed that a majority (61%) had hemoglobin levels below 10 gm/dL, indicating a high prevalence of anemia, a common complication in CKD due to reduced erythropoietin production. Regarding comorbidities, hypertension (38%) and diabetes (36%) were highly prevalent. Notably, 24% of the patients had both diabetes and hypertension, while only 2% had no comorbidities. The distribution of comorbidities was statistically significant (p = 0.012), underscoring the strong association of these conditions with CKD progression. [Table 1]

Table 2: Distribution of Study Population by CKD Stages and Hemodialysis Duration

CKD Stage / Hemodialysis Duration	Frequency (n)	Percentage (%)	P-Value
CKD Stage 1	14	14%	
CKD Stage 2	18	18%	
CKD Stage 3	20	20%	

CKD Stage 4	25	25%	
CKD Stage 5 (on Hemodialysis)	23	23%	0.004
Hemodialysis Duration			
└── Duration <1 year	5	21.7%	
└── Duration 1–3 years	14	60.8%	
└── Duration >3 years	4	17.4%	0.0249
Total	100	100%	

In the present study comprising 100 CKD patients, Stage 4 (25%) and Stage 5 (23%) were the most commonly observed stages, followed by Stage 3 (20%), Stage 2 (18%), and Stage 1 (14%). The distribution was statistically significant (p = 0.004), suggesting a greater burden of advanced CKD stages among the study population. Among the 23 patients with Stage 5 CKD who were on hemodialysis, the majority (60.8%) had been undergoing dialysis for 1–3 years, 21.7% for less than 1 year, and 17.4% for more than 3 years. This duration-wise distribution was also statistically significant (p = 0.0249), indicating that most patients were in the mid-phase of their dialysis journey, with a relatively lower proportion having long-standing exposure to hemodialysis. [Table 2]

Table 3: Distribution of Echocardiographic Changes in Study Population

Echocardiographic Changes	Number of Patients (N)	Percentage (%)	P-Value
Left Ventricular Hypertrophy (LVH)	59	59%	0.001
Left Ventricular Systolic Dysfunction (Total)	22	22%	0.049
Mild Left Ventricular Dysfunction (LVD)	12	12%	0.021
Moderate Left Ventricular Dysfunction	6	6%	0.021
Severe Left Ventricular Dysfunction	4	4%	0.021
Left Ventricular Diastolic Dysfunction (Total)	25	25%	0.033
Grade I Diastolic Dysfunction	21	21%	0.011
Grade II Diastolic Dysfunction	4	4%	0.011
Global Hypokinesia	18	18%	0.010
Regional Wall Motion Abnormality (RWMA)	6	6%	0.021
Valvular Heart Disease	17	17%	–
Pericardial Effusion	19	19%	0.001

Echocardiographic evaluation in the study population revealed a high prevalence of cardiac abnormalities, indicating significant cardiovascular involvement in chronic kidney disease (CKD). Left ventricular hypertrophy (LVH) was the most common finding, seen in 59% of patients (p = 0.001), reflecting chronic pressure overload likely due to hypertension and fluid retention. Left ventricular systolic dysfunction was present in 22% (p = 0.049), with a distribution of 12% mild, 6% moderate, and 4% severe dysfunction (all p = 0.021), suggesting a considerable burden of contractile impairment. Diastolic dysfunction was noted in 25% of patients (p = 0.033), with Grade I being the predominant form (21%) and Grade II in 4% (p = 0.011), highlighting the early onset of diastolic abnormalities in CKD. Global hypokinesia was observed in 18% (p = 0.010), while regional wall motion abnormalities (RWMA) were identified in 6% (p = 0.021), potentially indicating ischemic myocardial changes. Valvular heart disease was present in 17% of the patients, and pericardial effusion in 19% (p = 0.001), suggesting fluid overload or uremic pericarditis in advanced stages of renal dysfunction. [Table 3]

Table 4: Echo changes compared with hemoglobin values

Echocardiographic Changes	Hb< 10 gm/dL (N=61)	Hb ≥ 10 gm/dL (N=39)	P-Value
Left Ventricular Hypertrophy (LVH)	50 (82.0%)	9 (23.1%)	0.0003
Left Ventricular Dysfunction (LVD)	18 (29.5%)	4 (10.3%)	0.0001
Global Hypokinesia	15 (24.6%)	3 (7.7%)	0.002
Regional Wall Motion Abnormality (RWMA)	5 (8.2%)	1 (2.6%)	0.047
Valvular Heart Disease	12 (19.7%)	5 (12.8%)	0.015
Pericardial Effusion	10 (16.4%)	9 (23.1%)	0.001

The comparison of echocardiographic changes with hemoglobin levels revealed a strong association between anemia and cardiac abnormalities in CKD patients. Those with hemoglobin<10 gm/dL exhibited a markedly higher prevalence of left ventricular hypertrophy (82%) compared to those with Hb ≥10 gm/dL (23.1%), which was highly significant (p = 0.0003). Similarly, left ventricular dysfunction was more frequent in anemic patients (29.5% vs. 10.3%, p = 0.0001. Other abnormalities such as global hypokinesia (24.6% vs. 7.7%, p = 0.002), RWMA (8.2% vs. 2.6%, p = 0.047), and valvular heart disease (19.7% vs. 12.8%, p = 0.015) were also significantly more common in the anemic group. Interestingly, pericardial effusion was observed in both groups but slightly more in non-anemic patients (23.1%) compared to anemic patients (16.4%), with a statistically significant p-value (0.001). These findings highlight the critical influence of anemia on cardiac structure and

function in CKD, emphasizing the need for aggressive management of anemia to mitigate cardiovascular complications. [Table 4]

DISCUSSION

A cross-sectional study at the Department of Medicine and Department of Nephrology, MathuradasMathur Hospital, Jodhpur, included 100 CKD patients aged 18 and older. Men, women, and maintenance dialysis patients were enrolled. After obtaining informed consent, all patients had a thorough clinical examination and laboratory tests, including a complete blood count, renal function tests, serum electrolytes, liver function tests, blood glucose levels, and cholesterol Most patients had high blood creatinine and urea, electrolyte abnormalities, anaemia, and dyslipidaemia.

In our study, the majority of CKD patients were in the 41–50-year age group (39%), with a mean age of 50.5 ± 7.8 years ($p = 0.012$), suggesting a higher disease burden in middle-aged individuals. This finding is supported by Balananda et al,[10] who reported a similar mean age of 52.1 ± 10.3 years among CKD patients undergoing echocardiography, and by Reddy,[11] who found the predominant age group affected to be between 41 and 60 years, with a mean age of 55.2 years. Likewise, Barberato and Pecoits-Filho,[12] reported a younger but comparable mean age of 46.9 ± 12.8 years in a hemodialysis cohort, further corroborating the middle-aged predominance observed in our study. However, our findings contrast with those of Nazneen et al,[13] who reported a higher mean age of 59.6 years at the initiation of dialysis in patients with end-stage renal disease, indicating a slightly older affected population. In our study, males comprised 64% and females 36% of the CKD population, with no statistically significant difference ($p = 0.452$), suggesting a relatively equal impact of chronic kidney disease across genders. These findings are in agreement with Barberato and Pecoits-Filho,[12] who observed a similar male predominance in their cohort of hemodialysis patients undergoing echocardiographic evaluation. Likewise, Reddy,[11] reported a male-to-female ratio of approximately 60:40 in a study assessing ECG and echocardiographic findings in CKD patients, further supporting the trend seen in our results. Jameel et al,[14] also noted a higher percentage of male patients (around 63%) undergoing maintenance hemodialysis, indicating a consistent male predominance in CKD populations.

In our study, the majority of patients were in late CKD stages—Stage 4 (25%) and Stage 5 requiring dialysis (23%)—a distribution that was statistically significant ($p = 0.004$). This late-stage predominance is consistent with observations by Hussain et al. (2024),[15] who reported 36.5% of CKD patients in stage IV and noted a significant increase in echocardiographic abnormalities at these stages. Similarly, Rangabashyam et al,[16] found that patients in stages IV–V had significantly higher prevalence of left ventricular hypertrophy compared to earlier stages. These findings contrast with early-stage predominance seen in some community-based CKD cohorts, suggesting that hospital-based or dialysis-referred populations like ours tend to present at more advanced stages.

Echocardiographic evaluation in this study revealed a high burden of structural and functional cardiac abnormalities among patients with chronic kidney disease (CKD). The most prevalent finding was left ventricular hypertrophy (LVH), seen in 59% of patients ($p = 0.001$). This aligns with previous studies by Reddy et al,[11] who reported LVH in 56% of CKD patients, and Shinde et al,[17] who found a prevalence of 60%, reinforcing the notion that LVH is a prominent adaptive response to pressure and volume overload in CKD. Systolic dysfunction was detected in 22% of patients, with 12% classified as mild, 6% moderate, and 4% severe ($p = 0.021$). These results are consistent with the findings of Jameel et al,[14] who observed left ventricular systolic dysfunction in 20% of their CKD cohort. The high incidence of systolic impairment underscores the progressive nature of uremic cardiomyopathy and the role of myocardial fibrosis, volume overload, and prolonged hypertension in altering cardiac contractility. Diastolic dysfunction was present in 25% of cases, predominantly Grade I (21%) ($p = 0.033$). This supports the findings of Sachdeva et al, who observed diastolic dysfunction in 28.6% of their patients, with early-stage abnormalities being more prevalent. The development of diastolic dysfunction is thought to precede systolic dysfunction and is attributed to increased myocardial stiffness, interstitial fibrosis, and impaired relaxation, all of which are accelerated in CKD due to chronic inflammation, anemia, and mineral bone disease. Other echocardiographic abnormalities included global hypokinesia in 18% and regional wall motion abnormalities (RWMA) in 6% of patients, which may reflect silent myocardial ischemia or infarction—a known complication in advanced renal failure.[14]Valvular heart disease was observed in 17% of the population, consistent with Shinde et al,[17] who also reported valvular calcification and regurgitant lesions as common findings due to abnormal calcium-phosphate metabolism in CKD. Pericardial effusion was present in 19% of patients ($p = 0.001$), a significant observation. Reddy et al,[11] and Jameel et al,[14] reported similar findings, with pericardial involvement attributed to uremic pericarditis or volume overload in late-stage disease. Its early identification is crucial as it can progress to tamponade if not monitored. In our study, anemic CKD patients ($Hb < 10$ g/dL) exhibited significantly higher rates of cardiac abnormalities compared to non-anemic patients ($Hb \geq 10$ g/dL): LVH was present in 82% vs 23.1%, LVD in 29.5% vs 10.3%, and global hypokinesia in 24.6% vs 7.7% (all

$p < 0.01$). These robust associations underscore anemia as a key driver of cardiac remodeling and dysfunction in CKD. This is strongly supported by Baigent C et al, who reported a positive correlation between worsening anemia and increasing left ventricular mass index. Similar findings were observed by a pooled analysis of community‐based cohorts (including ARIC and Framingham), which demonstrated that anemia accompanied by LVH greatly elevates cardiovascular risk in CKD (HR ~4.1). Interventional studies, such as those by Io et al. and the ACORD trial, showed that correcting anemia (target Hb 11–13 g/dL) led to significant reductions in LV mass over time , indicating a direct pathophysiological link. Mechanistically, chronic anemia increases cardiac output and volume load, precipitating LV enlargement and impaired contraction—seen here as hypokinesia. The pattern observed aligns with BMC Nephrology's findings that improved hemoglobin correlates with reductions in LVMI during dialysis transition.

CONCLUSION

This cross-sectional study highlights a high prevalence of cardiovascular abnormalities in patients with chronic kidney disease, as detected by 2D-echocardiography. Left ventricular hypertrophy (59%) emerged as the most common echocardiographic finding, followed by systolic and diastolic dysfunction, pericardial effusion, and valvular heart disease. The presence of these abnormalities showed significant associations with advancing CKD stages, comorbidities such as diabetes and hypertension, and lower hemoglobin levels. Notably, patients with anemia and those with both diabetes and hypertension exhibited a greater burden of cardiac dysfunction. These findings underscore the critical importance of routine cardiac evaluation using 2D-echocardiography in CKD patients for early detection, risk stratification, and timely management of cardiovascular complications, which remain a leading cause of morbidity and mortality in this population.

REFERENCES

1. Webster AC, Nagler EV, Morton RL, Masson P. Chronic kidney disease. Lancet 2017;389:1238-5.
2. Glassock RJ, Warnock DG, Delanaye P. The global burden of chronic kidney disease: estimates, variability and pitfalls. Nat Rev Nephrol. 2017;13(2):104–14.
3. Gansevoort RT, Correa-Rotter R, Hemmelgarn BR, Jafar TH, Heerspink HJL, Mann JF, et al. Chronic kidney disease and cardiovascular risk: epidemiology, mechanisms, and prevention. Lancet Lond Engl. 2013;382(9889):339–52.
4. Adarsh L. S., Sravanthi Reddy, Manjunath S. Shetty.Asymptomatic cardiac manifestations in CKD. International Journal of Sciences.2018 ; 6 (3): 822.
5. Kidney Disease: Improving Global Outcomes (KDIGO) CKD Work Group. KDIGO 2012 Clinical practice guideline for the evaluation and management of chronic kidney disease. Kidney IntSuppl 2013; 1–150.
6. World Health Organization. Mortality and global health estimates: Causes of death; Projections for 2015–2030; Projection of death rates. http://apps.who.int/gho/data/node.main. PROJRATEWORLD?lang=en (accessed 29 June, 2016).
7. Reddy MA, Natarajan R. Recent developments in epigenetics of acute and chronic kidney diseases. Kidney Int 2015; 88: 250–61.
8. Anders HJ, Andersen K, Stecher B. The intestinal microbiota, a leaky gut, and abnormal immunity in kidney disease. Kidney Int 2013; 83: 1010–16.
9. Barberato SH, Pecoits-Filho R. Alteraçõesecocardiográficasempacientes com insuficiência renal crônicaemprograma de hemodiálise [Echocardiographic alterations in patients with chronic kidney failure undergoing hemodialysis]. Arq Bras Cardiol. 2010;94(1):140-6.
10. Balananda P, Bhansali S, Kiran AS. Echocardiographic findings in chronic kidney disease (CKD) patients. European Journal of Biomedical. 2016;3(9):451-9.
11. Reddy S. Assessment of ECG and Echo Findings among With Chronic Kidney Disease Patients. Sch. J. App. Med. Sci., 2017; 5(9A):3475-3480
12. Sachdeva S, Khurana T, Kaur S, Kamalpreet, Aggarwal R, Kaur A, Singh B. ECG and ECHO Changes in CKD. Ann. Int. Med. Den. Res. 2017; 3(5):ME10-ME14.
13. Nardi E, Mulè G, Nardi C, Geraci G, Giammanco A, Bentivegna R, Averna M. Is echocardiography mandatory for patients with chronic kidney disease?. Internal and emergency medicine. 2019;14:923-9.
14. Jameel FA, Junejo AM, Khan QUA, Date S, Faraz A, Rizvi SHM, Ahmad F, Tahir M. Echocardiographic Changes in Chronic Kidney Disease Patients on Maintenance Hemodialysis. Cureus. 2020;12(7):e8969.
15. Rangabashyam SR, Arul Murugan C, Kumar AA, Patil MG. A Study of Echocardiographic Assessment of Left Ventricular Abnormalities in Patients with Chronic Kidney Disease. Chettinad Health City Med J. 2023;12(1):17-23.
16. Yasir, Hussain.,Anjum, Shahzad., Sabha, Bhatti., Afia, Zafar., Bhushan, Shah., Muhammad, Irfan, Jamil., Adeel, Ahmed., Ayesha, Aamir. 3. The Spectrum of Echocardiographic Findings Across Stages I-V of Chronic Kidney Disease. Cureus, (2024). doi: 10.7759/cureus.65359
17. Mogely, Sh., Khubutiya., E., V., Shuvalova., O, Rzhevskaya., L., T., Khamidova., A., A., Ivannikov., Kh., G., Alidzhanova., A, G, Balkarov., I., V., Dmitriev. 5. Echocardiographic evaluation of myocardial structural and functional changes in patients with stage 5 chronic kidney disease before and after kidney transplantation. (2024). doi: 10.23873/2074-0506-2024-16-1-21-33.