Original Research Article

Left ventricular dysfunction among chronic kidney disease patients: a cross sectional study

Tarun Rao, Mohit Karwa, Anil Wanjari*

Department of Medicine, Jawaharlal Nehru Medical College, Wardha, Maharashtra, India

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*Correspondence:
Dr. Anil Wanjari,
E-mail: dranilwanjari@yahoo.com

ABSTRACT

Background: There is a significant worldwide burden of CKD; which is likely to increase further. Cardiovascular diseases constitute major cause of morbidity and mortality in CKD. LV dysfunction may be present despite the asymptomatic phase during the early stages of CKD. Thus, early detection of LV dysfunction and targeted interventions can improve prognosis in CKD.

Methods: This cross-sectional study was conducted among 250 CKD admitted patients. Echocardiographic examination was done to determine the systolic and diastolic function of LV. For LV systolic function ejection fraction and % fractional shortening were calculated and for LV diastolic function E/A, E/E', E deceleration time and IVRT were measured.

Results: Among 250 study subjects, 112 (47.8%) had systolic dysfunction and 138 (55.2%) had diastolic dysfunction. The prevalence of systolic as well as diastolic dysfunction increased significantly (P<0.05) with deteriorating renal function (39.1% for CKD stage 1 and 67.8% for stage 5 for systolic dysfunction, 34.8% for CKD stage 1 and 77.8% for stage 5 for diastolic dysfunction).

Conclusions: LV systolic and diastolic dysfunctions are significantly prevalent among CKD patients which increase with increasing severity of CKD. Hence, it is important to routinely screen these patients for LV dysfunction. The use of echocardiography can detect LV dysfunction at an early stage among the high-risk population of CKD to help plan appropriate strategies to slow the progression of cardiac dysfunction and improve prognosis.

Keywords: Chronic kidney disease, Echocardiography, Left ventricular dysfunction

INTRODUCTION

All over the globe chronic kidney disease (CKD) is imposing significant burden over healthcare. Trends pretend that it is likely to rise further in near future. The global estimate of CKD suggests a prevalence of 11-13%.1 CKD is closely associated with cardiovascular disease (CVD).

CVD is the major cause of mortality and morbidity in CKD patients, plus CKD also accelerates the pathophysiological abnormality of CVD.2,3 Usually, in the initial stages of CKD, individuals are asymptomatic. Even in the early stages of CKD, left ventricular (LV) dysfunction especially diastolic dysfunction is present.4 The LV diastolic dysfunction is associated with increased heart failure and death risk in CKD.5

Although, LV systolic dysfunction in CKD is less common than LV diastolic dysfunction; still nearly 15% of CKD patients starting hemodialysis have been found to have LV systolic dysfunction. Like diastolic dysfunction,
LV systolic dysfunction is a risk for heart failure in CKD. LV systolic dysfunction is associated with severe CAD and is a future predictor of congestive heart failure and poor prognosis. Proposed pathophysiology of LV dysfunction in CKD suggest that increased preload due to fluid overload, LV hypertrophy, myocardial fibrosis, microvascular abnormality, interstitial fibrosis, neuro-humoral (RAAS system) alterations are incriminatory. Interventions aimed at these pathophysiologic mechanisms can reverse or at least slow down the deterioration in LV function.

Hence, early detection of LV dysfunction with echocardiography in CKD patients can have a positive impact over the progressive decline in heart function provided appropriate therapy is instituted timely.

Thus, this study was aimed at determining the prevalence of LV diastolic and systolic dysfunction among CKD patients and evaluation of various parameters (E/A, E/E’, E deceleration time, IVRT, LVEF and %FS) of LV diastolic and systolic dysfunction in various stages of CKD.

**METHODS**

This cross-sectional study was started after obtaining approval from the institutional ethics committee (IEC no 1589). The study was conducted among patients of CKD getting admitted in various wards of Medicine department of Acharya Vinobha Bhave Rural Hospital (AVBRH) attached to Jawaharlal Nehru Medical College (JNMC), Sawangi, Wardha, Maharashtra (India) from 1st September 2015 to 31st August 2017.

The calculated sample size was 215 and 250 patients were finally considered. After explaining study procedures and objectives to all the CKD patients informed written consent was taken. Inclusion criteria was patients of CKD admitted to medicine wards during the study period.

Exclusion criterion included those with known valvular heart disease or congenital heart disease (CHD), known coronary artery disease (CAD) or previous myocardial infarction, chronic obstructive or restrictive pulmonary disease, chronic liver disease, poor echo window, connective tissue disorder, HIV, hypothyroidism, hyperthyroidism, those with in-situ pacemaker or implantable cardioverter defibrillator, cancer, immunosuppressive therapy, hypertrophic cardiomyopathy, not willing to participate in study, already enrolled once in this study. Using study questionnaire; demographic details, relevant medical history and physical examination findings were recorded.

Investigations like kidney function tests, liver function tests, serum electrolytes, fasting blood glucose, postprandial blood glucose, complete blood count and peripheral smear, ultrasound abdomen, chest X-ray (CXR), electrocardiography (ECG), and echocardiography were done. Glomerular Filtration Rate (GFR) was calculated using the CKD-EPI online formula for GFR calculation and accordingly staging of CKD was done.

For analysis purpose, we considered stage 3a and stage 3b as a combined stage and called it stage 3. On Echocardiography, for systolic function ejection fraction (EF) > 50% was considered normal and % fractional shortening (%FS) 30-50% was taken as normal.

For diastolic dysfunction, Doppler echo and tissue doppler were done. We calculated E/A (early diastolic mitral inflow velocity/late mitral inflow velocity), E/E’ (early diastolic mitral inflow velocity/ septal mitral annular tissue early velocity), E wave deceleration time and intraventricular relaxation time (IVRT). Standard age-specific reference values and grading of diastolic dysfunction were used to determine normal and abnormal for these parameters as well as classification of LV diastolic dysfunction.

The data was entered in Microsoft excel sheet. We used Stata version 13 software for statistical analysis and calculation of the prevalence of LV systolic and diastolic dysfunction. Means ± standard deviations (SD) of various parameters under study were calculated. χ2 test was used to compare categorical variable. A value of p < 0.05 was considered to indicate statistical significance.

**RESULTS**

Out of total 325 CKD patients admitted during study period, 75 were excluded (35 had diagnosed CAD, 21 were readmitted and already enrolled in the study, 15 had diagnosed CAD and 4 had COAD). 250 patients were finally considered for analysis.

All the study subjects were classified into three age groups (group 1- age 21-40 years, group 2 - 41-60 years, group 3- age more than 60 years).

Group 1 consisted of 27.2%, group 2 consisted of 52.8% and group 3 consisted of 20% of all participants. Of all the subjects; 114 (45.6%) were females and 136 (54.4%) were males. Mean age of study subjects was 49.7 years (SD 13.2). Hypertension was present in 77.6% (194) of the subjects; 114 (45.6%) were females and 136 (54.4%) were males. Mean age of study subjects was 49.7 years (SD 13.2). Hypertension was present in 77.6% (194) of subjects and 31.6% (79) of subjects were diabetic.

Table 1 depicts the EF, % FS, E/A, E/E’, IVRT and E deceleration time across various age groups. Mean EF was found decreased with age and was higher among males compared to females across age groups. Mean %FS decreased with age as its mean in the age group 21-40 years was 36.4 (SD, 8.1) and for age group >60 years was 36.1 (SD, 8.7) and was higher among males in all age groups.
Table 1: Age wise distribution of EF, % FS, E/A, E/E’, IVRT and E deceleration time.

| Age (in years) [Mean (S.D.)] | 21-40 Years | 41-60 Years | >60 years |
|-----------------------------|-------------|-------------|-----------|
|                             | Female      | Male        | Total     | Female      | Male        | Total     | Female      | Male        | Total     |
| IVRT (msec)                 | 76.5 (14)   | 76.7 (14.9) | 76.6 (14.5) | 76 (13.8)   | 76.3 (15.2) | 76.2 (14.5) | 70.8 (10.5) | 70.4 (9.2)  | 70.6 (9.7) |
| E/E’                        | 9.4 (2.4)   | 10.1 (2.5)  | 9.8 (2.4)  | 11 (2.8)    | 11.8 (2.9)  | 11.5 (2.9)  | 10.8 (2.7)  | 11.8 (2.8)  | 11.3 (2.8) |
| E dec (msec)                | 145.4 (23.5)| 153 (35.8)  | 149.8 (31.2)| 174.3 (41.3)| 176 (43.1)  | 175.3 (42.1)| 160.2 (41.9)| 166.1 (41.8)| 163.5 (41.8)|
| E/A                         | 1.25 (0.34) | 1.27 (0.25) | 1.26 (0.34)| 1.41 (0.53) | 1.44 (0.57) | 1.42 (0.55) | 1.46 (0.53) | 1.61 (0.52) | 1.54 (0.53)|
| EF                          | 48.9 (3.9)  | 49.7 (2.6)  | 49.4 (3.2) | 47.1 (7.7)  | 48.1 (6.8)  | 47.5 (7.2)  | 44.5 (8.9)  | 45.5 (9.5)  | 44.9 (9.2) |
| %FS                         | 35.9 (8.2)  | 36.7 (8.1)  | 36.4 (8.1) | 35.4 (7.6)  | 35.5 (6.8)  | 35.4 (7.2)  | 36.0 (9.1)  | 36.2 (8.5)  | 36.1 (8.7) |

Table 2: CKD stage and LV dysfunction

| Stages of CKD | Systolic dysfunction [Number (%)] | Diastolic dysfunction [Number (%)] |
|---------------|-----------------------------------|-----------------------------------|
|               | Absent | Present | OR | P value | Absent | Present | OR | P value |
| Stage 1       | 14 (61.9) | 9 (39.1) | 1 | 15 (65.2) | 8 (34.8) | 1 |
| Stage 2       | 21 (56.8) | 16 (43.2) | 1.18 | 16 (43.3) | 21 (56.7) | 2.5 |
| Stage 3       | 24 (55.8) | 19 (44.2) | 1.23 | 17 (39.5) | 26 (60.5) | 2.9 |
| Stage 4       | 27 (40.9) | 39 (59.1) | 2.25 | 16 (24.3) | 50 (75.7) | 5.9 |
| Stage 5       | 26 (32.1) | 55 (67.8) | 3.29 | 18 (22.2) | 63 (77.8) | 6.6 |
| Total         | 112 (47.8) | 138 (55.2) | | 82 (32.8) | 168 (67.2) | |

Table 3: Echo measures of LV systolic and diastolic dysfunction in different stages of CKD.

| Chronic kidney disease | Stage 1 | Stage 2 | Stage 3 | Stage 4 | Stage 5 |
|------------------------|---------|---------|---------|---------|---------|
| IVRT (msec)            | 74.3 (15.1) | 75.2 (13.9) | 72.6 (11.3) | 77.6 (14.5) | 74.6 (13.9) |
| E/E’                   | 9.1 (1.9) | 12.1 (3.7) | 11.1 (2.5) | 11.3 (2.1) | 11.8 (3.1) |
| E dec (msec)           | 150.4 (32.2) | 181.1 (47.3) | 166.2 (39.7) | 168.4 (40.5) | 161.4 (38.6) |
| E/A                    | 1.25 (0.18) | 1.33 (0.32) | 1.18 (0.54) | 1.34 (0.58) | 1.65 (0.47) |
| EF                     | 55.8 (3.5) | 55.3 (5.2) | 52.6 (4.2) | 54.5 (5.5) | 53.1 (6.1) |
| %FS                    | 37.5 (12.3) | 36.8 (9.1) | 36.3 (7.2) | 35.3 (6.3) | 35.0 (6.7) |

Table 4: Test characteristics of echo measures for LV diastolic dysfunction.

|                     | E/A (%) | E/E’ | E deceleration time | IVRT |
|---------------------|---------|------|---------------------|------|
| Sensitivity         | 91.12 (85.87-94.55) | 89.14 (83.67-92.94) | 90.53 (85.17-94.09) | 63.53 (56.07-70.39) |
| Specificity         | 81.48 (71.67-88.44) | 80 (69.59-87.49) | 72.84 (62.28-81.33) | 96.25 (89.55-98.72) |
| Positive predictive value | 91.1 (85.99-94.6) | 91.23 (86.03-94.61) | 87.43% (81.71-95.3) | 97.3 (92.35-99.08) |
| Negative predictive value | 81.6 (71.7-88.4) | 75.95% (65.46-84.03) | 78.67% (68.12-86.42) | 55.4 (47.1-63.4) |
| Likelihood ratio of positive test | 4.92 (3.78-5.17) | 4.45 (3.91-5.1) | 3.33 (3.05-3.65) | 16.94 (8.72-32.9) |
| Likelihood ratio of negative test | 0.11 (0.1-0.14) | 0.14 (0.12-0.15) | 0.13 (0.11-0.15) | 0.39 (0.37-0.61) |
| Diagnostic accuracy | 88% (83.4-91.5) | 86.4 (86.1-90.1) | 84.8 (79.83-88.72) | 74 (68.23-79.05) |
The E/A mean increased with age as the mean E/A in the age group 21-40 was 1.27 (SD, 0.25) and for age group >60 years was 1.54 (SD, 0.53). It was also found that the mean E/A was higher among females in all age groups. E deceleration time mean increased with age and was higher among males in all age groups. Mean IVRT was higher among males except those older than 60 years. E/E’ mean increased with age and was higher among males in all age groups.

As shown in Table 2, the prevalence of systolic dysfunction was 55.2% and diastolic dysfunction was 67.2%. We determined the trend of prevalence of LV dysfunction with stages of CKD and it was found that both systolic dysfunction (OR for stage 2 was 1.18 and for stage 5 was 3.29) and diastolic dysfunction (OR for stage 2 was 2.24 and for stage 5 was 6.6) increased in prevalence with more severe renal dysfunction. This trend was found to be statistically significant. Table 3 shows the mean along with standard deviation for EF, % FS, E/A, E/E’, IVRT and E deceleration time in different stages of CKD. Among these parameters, mean EF decreased from 55.8 (SD, 3.5) in CKD stage 1 to 53.1 (SD, 6.1) in CKD stage 5, mean %FS decreased from 37.5 (SD, 12.3) in CKD stage 1 to 35.0 (SD, 6.7) in CKD stage 5, mean E/A increased from 1.15 (SD, 0.18) in CKD stage 1 to 1.67 (SD, 0.47), mean of E deceleration time increased from 150.4 (SD, 32.2) in CKD stage 1 to 181.1 (SD, 47.3) in stage 2 and then decreased to 161.4 (SD, 38.6) in CKD stage 5. Mean E/E’ increased from 9.1 (SD, 1.9) in CKD stage 1 to 11.8 (3.1) in CKD stage 5. There was no specific trend observed with mean IVRT with increasing severity of CKD. Table 4 depicts the test characteristics of E/A, E/E’, E deceleration time and IVRT for diagnosis of LV diastolic dysfunction (along with the confidence intervals). It was found that E/A had the highest sensitivity and diagnostic accuracy and had the lowest negative likelihood ratio while IVRT had the highest specificity, positive predictive value and positive likelihood ratio.

**DISCUSSION**

We aimed at determining the prevalence of LV dysfunction in CKD patients admitted in Medicine department of JNMC, Sawangi (Wardha) and its attached AVBRH hospital and we found that among 250 CKD patients admitted in this hospital during the study period, 112 (47.8%) had systolic dysfunction and 138 (55.2%) had diastolic dysfunction. We also found that the prevalence of systolic as well as diastolic dysfunction increased significantly (P<0.05) with deteriorating renal function.

Heart and kidneys are two organs which are very closely related in context of hemodynamic and regulatory functions. The renin-angiotensin aldosterone system (RAAS), antidiuretic hormone, endothelin, and the natriuretic peptides are among the many, which are responsible for interrelatedness of heart and kidney function. As per international data, cardiac diseases account for 40% of deaths in dialysis population. In this study, CKD patients were found to have a high prevalence of systolic (47.8%) and diastolic dysfunction (55.2%). The prevalence of systolic dysfunction increased with increasing severity of renal impairment (39.1% in CKD stage 1 and 67.8% in CKD stage 5). A study by Nitin et al found that somewhat lesser i.e. 30.4% of CKD patients had systolic dysfunction and 56.5% had diastolic dysfunction. In that study and other studies also the prevalence of systolic dysfunction increased significantly with deteriorating renal function. Singal et al have reported in their study that 23% of study subjects had systolic dysfunction. Similarly, in a study conducted by Avijit Deb Nath et al, 15% of the patients with mild/moderate CKD had systolic dysfunction while 48% of patients with severe CKD had systolic dysfunction. However, some studies could not demonstrate significant systolic dysfunction in CKD patients. These varying results could be explained on the basis of differences inherent in the studied population by these authors and the methodology to diagnose LV dysfunction and CKD stages.

In this study, we found that 67.2% of subjects had diastolic dysfunction. There was a trend of increasing prevalence of diastolic dysfunction with deteriorating renal function (34.8% in CKD stage 1 and 77.8% in CKD stage 5). A similar study conducted by Nitin et al had found that 51.8% of patients with mild/moderate CKD had diastolic dysfunction, whereas 82.6% of patients with severe CKD had diastolic dysfunction. Lossi et al in a cross-sectional study among patient on maintenance hemodialysis observed that nearly 40% of the patients had diastolic dysfunction. Agrawal et had reported a prevalence of diastolic dysfunction of 30% in early stages of CKD and 53.2% in late stages of CKD. The differences between these observations can be explained on the basis of the different baseline characteristics of the population studied. These findings suggest that there is a significant burden of LV systolic and diastolic dysfunction in CKD patients.

Systolic function was assessed using LV ejection fraction and fractional shortening. Mean LVEF was within normal range in different stages of CKD but there was a declining trend with progressive stages of CKD. Similar trends had been noted by Agarwal et al also. However, another study did not find this trend of declining LVEF with progressive CKD. The present study found that mean %FS was almost similar in different stages of CKD, this observation is in contradiction to a few other studies which found a decline in %FS with progressive declining renal function. This suggests that although the LV systolic function shows a decline with deteriorating renal function but this may not be evident by observing the change in the mean of LVEF or %FS.

In this study, we found that E/E’ increased progressively with declining renal function (mean in CKD stage 1 was...
In present study, we found that E/A was the most sensitivity (91%) and IVRT was the most specificity (96%) parameter for the diagnosis of diastolic dysfunction. IVRT also had the highest positive predictive value (97%) and positive likelihood ratio (16.9). Diagnostic accuracy was highest for E/A (88%) which also had the lowest negative likelihood ratio. RICH-Q study has found that E/A ratio in children with the end-stage renal disease was less sensitive than E/E' to detect diastolic dysfunction. A recent study has reported that E/E' had a sensitivity of 81.4% and specificity of 55% respectively. While Issaz et al had reported a sensitivity of 81.4% Lee et al had reported that E/E' is more sensitive than E/A in detecting LV diastolic dysfunction. We have not studied others measures like pulmonary vein velocity. We used echo measures to establish diastolic dysfunction, hence when we determined test characteristics of different parameters we used echo derived diastolic dysfunction as standard. The test results would have been more reliable if other measures like invasively determined diastolic function would have been available. This was a limitation of present study and can be improved upon in future studies. Nevertheless, we have presented a significant report of LV function among CKD patients which can be used for present medical practice and used for future studies as well.

CONCLUSION

In conclusion, both LV systolic and diastolic dysfunction are significantly prevalent among CKD patients and these dysfunctions increase with increasing severity of CKD. Hence, it is important to routinely screen these patients for LV dysfunction. There are various modalities to determine LV dysfunction and echocardiography is one such important non-invasive method. Thus, the use of echocardiography can detect LV dysfunction at an early stage among the high-risk population of CKD to help plan appropriate strategies to slow the progression of cardiac dysfunction and improve prognosis. Test characteristics of various echo parameters of diastolic dysfunction suggest that they are a reliable mode of non-invasive diagnosis. Future studies focused on comparing individual echo parameter compared with invasively determined diastolic dysfunction can further establish their reliability.

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REFERENCES

1. Hill NR, Fatoba ST, Oke JL, Hirst JA, O'Callaghan CA, Lasserson DS, et al. Global prevalence of chronic kidney disease: a systematic review and meta-analysis. PLoS One. 2016;11(7):e0158765.
2. Go AS, Chertow GM, Fan D, McCulloch CE, Hsu CY. Chronic kidney disease and the risks of death, cardiovascular events, and hospitalization. New Engl J Med. 2004;351(13):1296-305.
3. Rule AD, Larson TS, Bergstralh EJ, Slezak JM, Jacobsen SJ, Cosio FG. Using serum creatinine to estimate glomerular filtration rate: Accuracy in good health and in chronic kidney disease. Annals Int Med. 2004;141(12):929-37.
4. Otsuka T, Suzuki M, Yoshikawa H, Sugi K. Left ventricular diastolic dysfunction in the early stage of chronic kidney disease. J Cardiol. 2009;54(2):199-204.
5. Kim MK, Kim B, Lee JY, Kim JS, Han BG, Choi SO, et al. Tissue Doppler-derived E/e' ratio as a parameter for assessing diastolic heart failure and as a predictor of mortality in patients with chronic kidney disease.
kidney disease. Korean J Int Med. 2013;28(1):35-44.
6. Hida S, Chikamori T, Tanaka H, Igarashi Y, Hatano T, Usui Y, et al. Diagnostic value of left ventricular function after adenosine triphosphate loading and at rest in the detection of multi-vessel coronary artery disease using myocardial perfusion imaging. J Nuclear cardiol American Soc Nuclear Cardiol. 2009;16(1):20-7.
7. Martin FL, McKie PM, Cataliotti A, Sangaralingham SJ, Korinek J, Huntley BK, et al. Experimental mild renal insufficiency mediates early cardiac apoptosis, fibrosis, and diastolic dysfunction: a kidney-heart connection. Am J Physiol Regulatory, Integrative Comparative Physiol. 2012;302(2):R292-9.
8. Sato W, Kosaka T, Koyama T, Ishida M, Iino K, Watanabe H, et al. Impaired renal function is a major determinant of left ventricular diastolic dysfunction: assessment by stress myocardial perfusion imaging. Ann Nuclear Med. 2013;27(8):729-36.
9. Masugata H, Senda S, Goda F, Yamagami A, Okuyama H, Kohno T, et al. Echocardiographic assessment of the cardio-renal connection: is left ventricular hypertrophy or diastolic function more closely correlated with estimated glomerular filtration rate in patients with cardiovascular risk factors? Clinical Experiment Hypertension (New York, NY:1993). 2010;32(2):113-20.
10. Segall L, Nistor I, Covic A. Heart Failure in Patients with Chronic Kidney Disease: A Systematic Integrative Review. BioMed Res Int. 2014;2014:21.
11. Sood MM, Pauly RP, Rigatto C, Komenda P. Left ventricular dysfunction in the haemodialysis population. NDT plus. 2008;1(4):199-205.
12. Matsushita K, Mahmoodi BK, Woodward M, Emerson JR, Jafar TH, Jee SH, et al. Comparison of risk prediction using the CKD-EPI equation and the MDRD study equation for estimated glomerular filtration rate. Jama. 2012;307(18):1941-51.
13. Zhu Y, Ye X, Zhu B, Pei X, Wei L, Wu J, et al. Comparisons between the 2012 new CKD-EPI (Chronic Kidney Disease Epidemiology Collaboration) equations and other four approved equations. PloS one. 2014;9(1):e84688.
14. Stevens PE, Levin A. Evaluation and management of chronic kidney disease: synopsis of the kidney disease: improving global outcomes 2012 clinical practice guideline. Ann Intern Med. 2013;158(11):825-30.
15. Naghue SF, Appleton CP, Gillebert TC, Marino PN, Oh JK, Smiseth OA, et al. Recommendations for the evaluation of left ventricular diastolic function by echocardiography. Journal of the American Society of Echocardiography: official publication of the Am Soc Echocardioc. 2009;22(2):107-33.
16. Naghue SF, Appleton CP, Gillebert TC, Marino PN, Oh JK, Smiseth OA. Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. J Am Society Echocardioc. 2016;29(4):277-314.
17. Nitin R R, Malay K G, Shah H. Assessment of cardiac dysfunction by 2D echocardiography in patients of chronic kidney disease. JPBMS, Vol. 17(17). 2012.
18. Bullock RE, Hassem AA, Simpson I et al. Cardiac abnormalities and exercise tolerance in patients receiving renal replacement therapy. BMJ 1984:28:1479-84.
19. Franczyk-Skora B, Gluba A, Olszewski R, Banach M, Rysz J. Heart function disturbances in chronic kidney disease - echocardiographic indices. Archives of medical science: AMS. 2014;10(6):1109-16.
20. Singal KK, Singal N, Gupta P, Chander J, Relan P. Cardiac status in patients of chronic kidney disease: an assessment by non-invasive tools. Bang J Med Sci. 2016;15(2):207-15.
21. Debnath A, Chaudhury SR, Nath A. Echocardiographic assessment of left ventricular systolic dysfunction in chronic kidney disease patients of a rural tertiary medical care centre in West Bengal. IOSR J Dent Med Sci. 2014;13(1):69-73.
22. Hayashi SY, Rohani M, Lindholm B, Brodin LA, Lind B, Barany P, et al. Left ventricular function in patients with chronic kidney disease evaluated by colour tissue Doppler velocity imaging. Nephrology, dialysis, transplantation: official publication of the European Dialysis and Transplant Association: European Renal Assoc. 2006;21(1):125-32.
23. Losi MA, Memoli B, Contaldi C, Barbati G, Del Prete M, et al. Myocardial fibrosis and diastolic dysfunction in patients on chronic haemodialysis. Nephrology, Dialysis, Transplant. 2010;25(6):1950-4.
24. Agarwal S, Danjri P, Kalra O, Rajpal S. Echocardiographic assessment of cardiac dysfunction in patients of chronic renal failure. J Indian Acad Clin Med. 2003;4(4):297.
25. Cioffi G, Tarantini L, Faggiano P, Puligiano G, Russo G, Di Lenarda A. Left ventricular systolic dysfunction in chronic kidney disease: from asymptomatic changes in geometry and function to overt heart failure. Monaldi Archives Chest Dis. 2015;82(1):10-5.
26. Cioffi G, Tarantini L, Frizzi R, Stefenedelli C, Russo TE, Selmi A, Toller C, Furlanello F, de Simone G. Chronic kidney disease elicits excessive increase in left ventricular mass growth in patients at increased risk for cardiovascular events. J Hypertens. 2011;29(3):565-73.
27. Laddha M, Sachdeva V, Digikar PM, Satpathy PK, Kakrani AL. Echocardiographic assessment of cardiac dysfunction in patients of end stage renal
disease on haemodialysis. J Assoc Physicians India. 2014;62(1):28-32.

28. Poorrafsanjani MH, Darabad BR. Evaluate the sensitivity and specificity echocardiography in trans-Doppler and tissue Doppler method in the estimation of left ventricular end-diastolic pressure. Global J Health Sci. 2014;6(7):92-7.

29. Isaaz K, Munoz del Romeral L, Lee E, Schiller NB. Quantitation of the motion of the cardiac base in normal subjects by Doppler echocardiography. J Am Society Echocardio. 1993;6(2):166-76.

30. Lee SW, Park MC, Park YB, Lee SK. E/E’ ratio is more sensitive than E/A ratio for detection of left ventricular diastolic dysfunction in systemic lupus erythematosus. Lupus. 2008;17(3):195-201.

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