REVIEW ARTICLE

Echocardiographic Finding in Chronic Kidney Disease Patients on Hemodialysis in Al-Diwaniyah Teaching Hospital
Cross section –descriptive study in AL-Diwaniyah Teaching Hospital

Meld Qasim Kamal[1], Aqeel Raheem AL-Barqawee[2]

1Permanent Resident/ AL-Diwaniyah Health Directorate/AL-Diwaniyah Teaching Hospital/AL-Diwaniyah province/ Iraq

2Consultant physician/ Professor/ Department of Medicine/College of medicine /AL-Qadisiyah University

Corresponding Email:milad2021qa@gmail.com

Abstract:

Background Chronic kidney disease is the irreversible decline of renal function, resulting in metabolic disturbance, the weakening of excretory, and endocrine roles. This leads to the emergence of the medical condition known as uremia. Individuals afflicted by chronic kidney disease has a heightened susceptibility to both morbidity and mortality attributed to cardiovascular ailments. The risk of cardiovascular mortality among patients undergoing dialysis is 10 to 30-fold when compared to the general populace. Within patients on long-term dialysis, cardiovascular illness stands as the primary source of death

Objective: To investigate diverse cardiovascular alterations in persons with chronic kidney illness who are suffering hemodialysis, by two- dimensional echocardiography.

Patients and Methods: A descriptive cross-sectional study conducted from the 12th of March to the 10th of June in the year 2023 at the Al-Zahraa Dialysis Center within Al-Diwaniyah Teaching Hospital. The study included 64 patients on hemodialysis, detailed history and examination were performed for every patient. The echocardiography examination was done for all involved patients and information was examined by means of SPSS version 26.

Results: the mean age stayed 56.47 and mean of Body mass index was 27.21 on dialysis patients, The family history of chronic kidney disease, diabetic mellitus, smoking history and history of hepatitis B and C were a risk factor, ECG show sign of hyperkalemia Only 18.7% of dialysis - patients had normal echo finding.

Conclusion:Irregular echocardiographic observations were notably prevalent among patients undergoing dialysis, with abnormality being left ventricular hypertrophy, succeeded by valvular disorders

Key words: Echocardiogram, hemodialysis, LVH hypertrophy

Introduction

chronic kidney disease (CKD) comprises a series of diverse pathophysiological mechanisms linked to anomalous kidney function and a gradual reduction in glomerular filtration rate (GFR) (1). Globally, CKD stands as a significant public health concern, exhibiting an escalation in both its incidence and prevalence. The definition of CKD entails kidney impairment persisting for over 3 months, characterized by fundamental or purposeful irregularities of the kidney. This condition may occur with or without a decline in GFR and is evident through either pathological anomalies or indicators of kidney impairment. These markers encompass deviations in blood or urine composition, as well as abnormalities detected through imaging tests (2).Cardiovascular disease (CVD) stands as a primary contributor to both mortality and morbidity in individuals afflicted by - chronic kidney disease . A significant proportion of CKD patients experience CVD-related fatalities even before progressing to end-stage CKD. Consequently, the emphasis on patient care during the earlier stages of CKD should be channeled toward averting cardiovascular difficulties (1, 3). A robust connection occurs among CKD and CVD, evidenced by an escalating incidence of CVD as the glomerular filtration rate (GFR) regressions. Indeed, cardiovascular disease is the main cause of morbidity and mortality among CKD patients (4)

Patients in the end-stage renal disease (ESRD) category frequently exhibit echocardiographic irregularities. Delineating the spectrum of echocardiographic anomalies in these patients' potential in mitigating cardiovascular risks. Consequently, a recommended practice involves periodic echocardiographic assessments for the identification and management of cardiac (5). Among CKD patients undergoing hemodialysis, alterations in cardiac structure and function discerned through echocardi-

ography are commonplace, and these

changes have been identified as pivotal predictors of outcomes. Notably, the cardiovascular mortality rate in this demographic is 10 to 20 times upper compared to the universal populace (6). Individuals affected by chronic kidney disease (CKD) face a substantially elevated susceptibility to experiencing heightened rates of both morbidity and mortality resulting from cardiovascular disease (CVD).patients on dialysis have a 10-to 30-fold increased risk for cardiovascular mortality compared with the general population.Notably, CVD emerges as the primary contributor to mortality in patients undergoing extended periods of dialysis, constituting 44% of the total mortality rate. This issue's magnitude has grown more pronounced due to the extended survival periods of patients undergoing maintenance hemodialysis (7).

There were few studies regarding echo finding amongst patients with CKD in Iraq and this training was performed to refill the gap on the missed information and our study also intended to detect the factors affecting the in Iraq.

Aim of study: To study various cardiovascular changes in chronic kidney illness patients on dialysis with help of two dimensional echocardiography.

Patients and Methods:

A descriptive cross-sectional study with a hospital-based method was undertaken. The data collection phase took place between the 12th of March and the 10th of June in the year 2023. This study was carried out among patients within the nephrology unit of the Al-Zahraa Dialysis Center, situated within the premises of the Al-Diwaniyah Teaching Hospital in the Al-Diwaniyah governorate. The data collection was done in about five hours per day for four days weekly.

The study included patients with CKD on maintenance dialysis with CKD stage 4,5 of both genders and age more than or equal to 15 to 70 years. Patient with history of renal transplantation, obvious medical indication of coronary artery illness, valvular heart illness, rheumatic heart sickness, congenital heart syndrome and prime cardiomyopathy stayed excepted from the training also sick who referred from other provinces. One tool used to collect the required data and this tool was self-constructed questionnaire form prepared to collect information from the participants regarding selected variables. Information's for establishing the questionnaire form were obtained from reviewing previously published articles and from consultation of family medicine and cardiologist specialists. The data was collected by direct interview with participants. The first part of the questionnaire included information about socio-demographic characteristics of patients and past medical history and includes fourteen questions. Every patient underwent a comprehensive clinical assessment, encompassing a thorough evaluation. For the purpose of determining body mass index (BMI), the patients' weight in kilograms (Kg) and elevation in meters (m) were meticulously recorded. BMI was then designed using the next formula: $BMI = Kg/m^2$. The BMI values were subsequently categorized as follows:

- Underweight: BMI less than 18.5
- Normal: BMI ranging from 18.5 to 24.9
- Overweight: BMI ranging from 25 to 29.9
- Obese: BMI of 30 and above (committee 1995).

The 2D echocardiography assessments were carried out using a Vivid S5 echocardiography machine equipped with a 3 Mega

hertz probe. During the echocardiographic evaluation of CKD patients, a left lateral position was adopted. The examination comprised a comprehensive analysis conducted through various views, which included: 1. Left parasternal long axis, 2. Left parasternal short axis.

3. Apical- 4 chambers, 5 chambers (for aortic valve flow), 2 chambers, and 3 chambers. 4. M mode for determining both structural and functional cardiac parameters.

sick with a left ventricular ejection fraction (EF) below 50% were diagnosed with left ventricular dysfunction. The assessment of left ventricular diastolic dysfunction involved the calculation of the E/A ratio using Doppler velocity measurements. An E/A ratio below 0.75 or above 1.8 stood identified as analytic of left ventricular diastolic dysfunction. Patients presenting with an intraventricular width or left ventricular posterior wall width equal to or exceeding 12mm were diagnosed with left ventricular hypertrophy (LVH).

Ethical considerations:The necessary approvals were gained from the ethical commission within the Branch of Family and Community Medicine at Al-Qadisiyah College of Medicine. Additionally, formal agreement was secured from the Al-Diwaniyah Health Directorate, granted on the 10th of July in the year 2023 (referenced by number 13). The formal approval was obtained from the Iraqi Ministry of Health, signifying the endorsement of the training. Contributors stayed providing with a comprehensive explanation of the study's objectives, ensuring they were informed before obtaining their verbal consent to participate.

Statistical analysis:

The collected data underwent analysis utilizing the Statistical Set for the Social Sciences (SPSS) software program, version 26. After being extracted from each patient, the data was then transferred to a Microsoft Excel spreadsheet on a Windows platform for further processing and evaluation.

Descriptive statistics were displayed using frequency tables. Incessant variables stayed represented as average standards along with their corresponding standard deviations. Unconditional variables were existing as numerical counts and proportions.

For analytical statistics, the chi-square examination was employed to ascertain any relations among two unconditional variables. A P-value equivalent to or fewer than 0.05 stayed measured to designate statistical importance.

Results:

1. Demographic features of sick registered in this training where Mean age of patients with dialysis was 56.47 .while Mean of BMI (body mass index) was 27.21 where Normal weight 34 ,over weight 18 ,obese 12.According to gender in dialysis patients was male higher than female ,Also there was different in marital status on dialysis group where married more thansingle,anotherdescriptivestudyshownintable1

2.History of chronic medical illnesses of patients enrolled in this study .where Family history of chronic kidney illness in dialysis group was 20 ,History of Hypertension and diabetes mellitus (50,20)respectively, History Hepatitis virus HBV,HCV was (20,24) respectively ,and Smoking was 22.shown in table 2.3.ECG findig in patients enrolled inthis study where positive has sign of hyperkalemia show in table 3

5.Echo findings in patients enrolled in this study where Abnormal echo finding in dialysis group was more than normal (52,12

)respectively where valvular heart disease more in MR than AR ,TR,PR (24,12,14,0) ,LVH in dialysis group was42, pericardial effusion was 18 ,and global hypokinesia was 4 , Ejection friction (EF) in dialysis group were more normal than decrease(56, 8),shown in table 4.

Discussion:

Echocardiography serves as a valuable tool for assessing the purposeful and fundamental changes in the heart that stem from chronic kidney illness (CKD)(9). Consequently, evaluating echocardiographic parameters among CKD patients can aid in the determination of cardiovascular illness (CVD) danger and prognosis in this patients (10).

In the existing training, it was detected that the average age of patients undergoing dialysis stayed 56.47 year. Similar results were obtained in trainings via Zhu et al. and Janjua et al., where the average ages of patients undergoing dialysis were 52.14 and 55.85 years, respectively(11,12).

Gender distribution in the dialysis group indicated a higher prevalence of males. This aligns with a meta-analysis of various studies that suggested a quicker development of CKD in men compared to females (13).

The   (BMI) in the dialysis grouping stayed found to be 27.21. This finding corresponds with descriptive studies reporting a positive correlation between obesity and end-stage renal disease (ESRD). Evidence supports obesity as an independent danger feature for ESRD, as demonstrated in studies like the one conducted by Mohammedi et al.(14).

Remarkably, only 9.4% of individuals in the dialysis group were employed. This could potentially be attributed to the prolonged period of dialysis management and the difficulties associated with kidney illness, leading to initial departure among CKD patients . This trend is consistent with findings from trainings via Shahrin et al. and Guerra et al.(15,16).The marital status shown ; where patients in dialysis group were married 81.3%while single group were 18.8%, A similar finding shown that 52% of patients on dialysis were married (17).The presence of a family history among patients with (CKD) was identified in 31.1% of sick with (ESRD). This aligns with the findings from Song et al.'s study, conducted in the United States, which revealed that approximately 23% of occurrence dialysis sick had close relations affected by ESRD(18).

Diabetes mellitus and hypertension established as pivotal danger features for CKD, particularly in developed regions. This trend was reflected in the current study, where hypertension was diagnosed in 78.1% of dialysis patients and diabetes mellitus in 31.3%. Similar findings were reported by Adhikaree et al., with hypertension among 92.2% and diabetes mellitus among 37.4% of the hemodialysis group(19).

A smoking history was observed in 34.4% of the dialysis group. Orth et al.'s study supported this link, indicating that an increase in smoked cigarettes per day correlated with a greater likelihood of elevated serum creatinine levels(20).

The prevalence of hepatitis B and C stayed 31.3% and 37.5%, separately, in the dialysis group. These figures surpassed the reported prevalence rates of 8%-10% in the United States among patients with ESRD. The disparity in prevalence might be attributed to suboptimal infection control practices within hemodialysis centers.

ECG is asimple ,non -invasive and available tool in daily routine practice and in patients with CKD ,hyperkalemia is common and life-threating,the current study shown there was 21.9% of dialysis patients had a sign of hyperkalemia by ECG in one large cohort of patients with stage 3 and 4 CKD prevelence of hyperkalemia was 11% (21)

Echocardiography has been established as the standard for assessing valvular heart disease (VHD) in CKD/ESRD patients. The study indicated that mitral regurgitation (MR) was the greatest mutual form of VHD, surveyed via aortic regurgitation (AR) and tricuspid regurgitation (TR). This pattern was consistent with other research highlighting mitral valve disease as the predominant form among patients with renal insufficiency(22,23,24). The existing training discovered that only 34.4% of patient in the dialysis group exhibited a normal left ventricle. This trend is in accordance with findings from studies like Laddha et al., where left ventricular hypertrophy (LVH) stayed existing in 74.3% of cases(3). Park's study also supported this, demonstrating that a reduction in kidney function was considerably related with irregular left ventricular (LV) geometry, with an eGFR of 30–44 ml/min per 1.73 m² considerably linked to LVH and abnormal LV geometry paralleled to an eGFR of ≥60 ml/min per 1.73 m²(25). The development of LVH can arise from factors such as augmented preload owing to hypervolemia, or heightened afterload resulting from elevated peripheral fighting or hypertension—both prevalent in CKD patients. Furthermore, great cardiac production owing to anemia or arteriovenous fistulas for dialysis admission could contribute to LVH pathogenesis(26,27).

Mild left ventricular systolic dysfunction stayed identified in 6.2% of the dialysis group, a result similar to Wang et al.'s findings, which indicated that LV hypertrophy was frequently accompanied by LV dilatation and systolic dysfunction(28). Echocardiographic assessment of diastolic dysfunction among dialysis sick with CKD showed a great occurrence of irregularities(29,30). Some studies have even suggested that tissue Doppler velocity abnormalities are virtually present in all CKD patients, indicating the existence of subclinical myocardial disease(31). In the CRIC training involving phase 2–4 CKD patients, 71% exhibited abnormal diastolic function(25). Pericardial effusion was 28.1% in patient with dialysis (21.9%of patients had mild pericardial effusion, 3.1% of patients had moderate pericardial effusion and 3.1% of patients had sever pericardial effusion), this similar to a recent study that shown that a symptomatic pericardial effusion was prevalent among 30% of dialysis patients(32). Furthermore, Laddha et al.'s study revealed that amongst hemodialysis ESRD and chronic kidney illness sick, the existence of pericardial effusion was noted to be 14.3%(3).

In the context of patients on dialysis, a prevalence of 6.3% for global hypokinesia was observed. This agrees with the outcomes of Kartheek et al.'s study, which indicated a similar prevalence of 16% for global hypokinesia among patients with (ESRD)(33). There stayed significant difference in EF% were decrease EF% was 12.5% , approximately similar finding was found by Escoli et al study, where 19% of dialysis patients had reduce EF% (34).

Conclusion:

The mean age of dialysis group was 56.4 years,ECG had asign of hyperkalemia. Echo finding was normal among 18.7% of dialysis group. Left ventricular hypertrophy emerged as the predominant echocardiographic abnormality detected among patients with   (CKD). In terms of valvular heart diseases, mitral regurgitation was identified as the most prevalent among CKD patients,

surveyed via aortic regurgitation and tricuspid regurgitation.

Table .1. Demographic features of sick registered in this training:

Characteristic		Dialysis group n = 64
Age (years)	Mean ± SD	56.47 ± 15.15
	Range	21-70
BMI (kg/m²)	Mean ± SD	27.21 ± 3.10
	Range	20.81 -36.72
	Normal weight	34 (53.1 %)
	Over weight	18 (28.1 %)
	Obese	12 (18.8 %)
Sex	Male	36 (56.3 %)
	Female	28 (43.8 %)
Occupation	No job	32 (50.0 %)
	Housewife	26 (40.6 %)
	Employee	6 (9.4 %)
Marital status	Single	12 (18.8 %)
	Married	52 (81.3 %)

Table .2. History of chronic medical illnesses of patients enrolled in this study

Characteristic		Dialysis group n = 64
Family HX of CKD	Negative	44 (68.8 %)
	Positive	20 (31.3 %)
HTN	Negative	14 (21.9 %)
	Positive	50 (78.1 %)
DM	Negative	44 (68.8 %)
	Positive	20 (31.3 %)
Smoking	Non smoker	42 (65.6 %)
	Smoker	22 (34.4 %)
HBV	Negative	44 (68.8 %)
	Positive	20 (31.3 %)
HCV	Negative	40 (62.5 %)
	Positive	24 (37.5 %)

Table .3.Result of ECG finding

characteristic		Dialysis group
ECG	Normal	50 (78.1 %)
	Sign of hyperkalemia	14 (21.9 %)

Table .4 .Echo finding result in this study

Characteristic		Dialysis group n = 64
Echo finding	Normal	12 (18.75 %)
	Abnormal	52 (81.25 %)
AR	None	52 (81.3 %)
	Mild	10 (15.6 %)
	Moderate	2 (3.1 %)
MR	None	40 (62.5 %)
	Mild	14 (21.9 %)
	Moderate	10 (15.6 %)
TR	None	50 (78.1 %)
	Mild	6 (9.4 %)
	Moderate	6 (9.4 %)
	Sever	2 (3.1 %)
LVH	None	22 (34.4 %)
	Mild	30 (46.9 %)
	Moderate	6 (9.4 %)
	Sever	6 (9.4 %)
LV systolic dysfunction	None	60 (93.8 %)
	Mild	4 (6.2 %)
Diastolic dysfunction Grade	Normal	38 (59.4 %)
	1	26 (40.6 %)
Pericardial effusion	Normal	46 (71.9 %)
	Small	14 (21.9 %)
	Moderate	2 (3.1 %)
	Large	2 (3.1 %)
Global hypokinesia	Negative	60 (93.8 %)
	Positive	4 (6.3 %)
EF %	Normal	56 (87.5 %)
	Decreased	8 (12.5 %)

References:

1. 2Skorecki K, Bargman J. Chronic Kidney Disease. Harrison's Principals of Internal Medicine. Newyork: McGraw-Hill Inc. 201;18(2):2308.

2. upplemeKovesdy CP. Epidemiology of chronic kidney disease: an update 2022. Kidney International Snts. 2022;12(1):7-11. https://doi.org/10.1016/j.kisu.2021.11.003

3. Laddha M, Sachdeva V, Diggikar P, Satpathy P, COMMITTEE, W. E. 1995. Physical status: the use and interpretation of anthropometry. World Health Organ Tech Rep Ser., 854, 312-344Kakrani A. Echocardiographic assessment of cardiac dysfunction in patients of end stage renal disease on haemodialysis. J Assoc Physicians India. 2014;62(1):28-32. https://doi.org/10.15586/jrenhep.v5i1.98

4. Lesaffre F, Wynckel A, Nazeyrollas P, Rieu P, Metz D. Echocardiography to predict adverse cardiac and

vascular events in patients with severe chronic kidney disease (stage 4): a prospective study. Archives of Cardiovascular Diseases. 2013;106(4):220-7. https://doi.org/10.1016/j.acvd.2013.01.005

5. Ostovan M, RAEIS JGA, MAZLOUM Z, ROUZBEH J, Sagheb M. Spectrum of echocardiographic abnormalities in end-stage renal disease patients undergoing hemodialysis. 2008.

6. Barberato SH, Pecoits-Filho R. Echocardiographic alterations in patients with chronic kidney failure undergoing hemodialysis. Arquivos brasileiros de cardiologia. 2010;94:140-6. https://doi.org/10.1590/S0066-782X2010000100021

7. Bethesda M. US Renal Data System: USRDS 2004 Annual Data Report: The National Institutes of Health. National Institute of Diabetes and Digestive and Kidney Diseases. 2004.

8. COMMITTEE, W. E. 1995. Physical status: the use and interpretation of anthropometry. World Health Organ Tech Rep Ser., 854, 312-344

9. Gori M, Senni M, Gupta DK, Charytan DM, Kraigher-Krainer E, Pieske B, et al. Association between renal function and cardiovascular structure and function in heart failure with preserved ejection fraction. European heart journal. 2014;35(48):3442-51. https://doi.org/10.1093/eurheartj/ehu254.

10. Tsilonis K, Sarafidis PA, Kamperidis V, Loutradis C, Georgianos PI, Imprialos K, et al. Echocardiographic parameters during long and short interdialytic intervals in hemodialysis patients. American Journal of Kidney Diseases. 2016;68(5):772-81. https://doi.org/10.1053/j.ajkd.2016.06.017

11. Zhu X, Jing R, Li X, Zhang W, Tang Y, Liu T. Left ventricular hypertrophy, carotid atherosclerosis, and cognitive impairment in peritoneal dialysis patients. BMC Cardiovascular Disorders. 2023;23(1):1-9. https://doi.org/10.1186/s12872-023-03130-

12. Janjua TK, Mukhtar KN, Naveed AK, Ahmed EB, Rehan M. Frequency of maintenance hemodialysis patients meeting K/DOQI criteria for serum calcium, phosphorus, calcium phosphorus product and PTH levels; a single institutional experience from Pakistan: a cross sectional study. The Pan African Medical Journal. 2019;33.

13. Neugarten J, Golestaneh L, editors. Influence of sex on the progression of chronic kidney disease. Mayo Clinic Proceedings; 2019: Elsevier. https://doi.org/10.1016/j.mayocp.2018.12.02.

14. Mohammedi K, Chalmers J, Herrington W, Li Q, Mancia G, Marre M, et al. Associations between body mass index and the risk of renal events in patients with type 2 diabetes. Nutrition & diabetes. 2018;8(1):7.https://doi.org/10.1038/s41387-017-0012-

15. Shahrin FIM, Yu LZ, Omar N, Zakaria NF, Daud ZAM. Association of socio-demographic characteristics, nutritional status, risk of malnutrition and depression with quality of life among elderly haemodialysis

patients. Malaysian Journal of Nutrition. 2019;25(1). doi: https://doi.org/10.31246/mjn-2018-0101

16. Guerra-Guerrero V, Sanhueza-Alvarado O, Cáceres-Espina M. Quality of life in people with chronic hemodialysis: association with sociodemographic, medical-clinical and laboratory variables. Revista latino-americana de enfermagem. 2012;20:838-46. https://doi.org/10.1590/S0104-116920120005000.

17. Schouten RW, Haverkamp GL, Loosman WL, Shaw PKC, van Ittersum FJ, Smets YF, et al. Anxiety symptoms, mortality, and hospitalization in patients receiving maintenance dialysis: a cohort study. American Journal of Kidney Diseases. 2019;74(2):158-66. https://doi.org/10.1053/j.ajkd.2019.02.017

18. Song E-Y, McClellan WM, McClellan A, Gadi R, Hadley AC, Krisher J, et al. Effect of community characteristics on familial clustering of end-stage renal disease. American journal of nephrology. 2009;30(6):499-504. https://doi.org/10.1159/000243716

19. Adhikaree A, Amrit K, Triphatee A, Thakuri SBH, Thapa S, Regmi K, et al. Cardiac Evaluation of Chronic Kidney Disease Patients under Maintenance Hemodialysis. Nepal Journal of Medical Sciences. 2022;7(2):30-7.

20. Orth SR, Schroeder T, Ritz E, Ferrari P. Effects of smoking on renal function in patients with type 1 and type 2 diabetes mellitus. Nephrology Dialysis Transplantation. 2005;20(11):2414-9. https://doi.org/10.1093/ndt/gfi022

21. NAKHOUL, G. N., HUANG, H., ARRIGAIN, S., JOLLY, S. E., SCHOLD, J. D., NALLY JR, J. V. & NAVANEETHAN, S. D. 2015. Serum potassium, end-stage renal disease and mortality in chronic kidney disease. American journal of nephrology, 41, 456-463

22. Kuźma Ł, Małyszko J, Bachórzewska-Gajewska H, Niwińska MM, Kurasz A, Zalewska-Adamiec M, et al. Impact of chronic kidney disease on long-term outcome of patients with valvular heart defects. International Urology and Nephrology. 2020;52:2161-70. https://link.springer.com/article/10.1007/s11255-020-02561-4#citeas:~:text=DOI-,https%3A//doi.org/10.1007/s11255%2D020%2D02561%2D4,-Share%20this%20article

23. Marwick TH, Amann K, Bangalore S, Cavalcante JL, Charytan DM, Craig JC, et al. Chronic kidney disease and valvular heart disease: conclusions from a Kidney Disease: Improving Global Outcomes (KDIGO) Controversies Conference. Kidney international. 2019;96(4):836-49. https://doi.org/10.1016/j.kint.2019.06.025

24. Hensen LC, El Mahdiui M, van Rosendael AR, Smit JM, Jukema JW, Bax JJ, et al. Prevalence and prognostic implications of mitral and aortic valve calcium in patients with chronic kidney disease. The American Journal of Cardiology. 2018;122(10):1732-7. https://doi.org/10.1016/j.amjcard.2018.08.009

25. Park M, Hsu C-y, Li Y, Mishra RK, Keane M, Rosas SE, et al. Associations between kidney function and subclinical cardiac abnormalities in CKD. Journal of the American Society of Nephrology. 2012;23(10):1725-34.

26. Fearnley CJ, Roderick HL, Bootman MD. Calcium signaling in cardiac myocytes. Cold Spring Harbor perspectives in biology. 2011;3(11):a004242. Cold Spring Harb Perspect Biol 2011; doi: 10.1101/cshperspect.a004242 originally published online

27. London GM. Left ventricular alterations and end-stage renal disease. Nephrology Dialysis Transplantation. 2002;17(suppl_1):29-36. https://doi.org/10.1093/ndt/17.suppl_1.29

28. Wang AY, Wang M, Lam CW, Chan IH, Zhang Y, Sanderson JE. Left ventricular filling pessure by Doppler echocardiography in patients with end-stage renal disease. Hypertension. 2008;52(1):107-14. https://doi.org/10.1161/HYPERTENSIONAHA.108.112334

29. Takase H, Dohi Y, Toriyama T, Okado T, Tanaka S, Shinbo H, et al. B-type natriuretic peptide levels and cardiovascular risk in patients with diastolic dysfunction on chronic haemodialysis: cross-sectional and observational studies. Nephrology Dialysis Transplantation. 2011;26(2):683-90. https://doi.org/10.1093/ndt/gfq408

30. Sharma R, Gaze DC, Pellerin D, Mehta R, Gregson H, Streather CP, et al. Cardiac structural and functional abnormalities in end stage renal disease patients with elevated cardiac troponin T. Heart. 2006;92(6):804-9. http://dx.doi.org/10.1136/hrt.2005.069666

31. Rakhit DJ, Zhang XH, Leano R, Armstrong KA, Isbel NM, Marwick TH. Prognostic role of subclinical left ventricular abnormalities and impact of transplantation in chronic kidney disease. American heart journal. 2007;153(4):656-64. https://doi.org/10.1016/j.ahj.2007.01.028

32. Farshid A, Pathak R, Shadbolt B, Arnolda L, Talaulikar G. Diastolic function is a strong predictor of mortality in patients with chronic kidney disease. BMC nephrology. 2013;14(1):1-6. https://bmcnephrol.biomedcentral.com/articles/10.1186/1471-2369-14-280#citeas:~:text=DOI-,https%3A//doi.org/10.1186/1471%2D2369%2D14%2D280,-Share%20this%20article

33. Kartheek AV, Reddy VS. Assessment of cardiac dysfunction in patients with end stage renal disease in a tertiary care hospital. J Evid Based Med Health. 2019;6(24):1668-72.

34. Escoli R, Carvalho MJ, Cabrita A, Rodrigues A. Diastolic dysfunction, an underestimated new challenge in dialysis. Therapeutic Apheresis and Dialysis. 2019;23(2):108-17. https://doi.org/10.1111/1744-9987.12756