

ORIGINAL ARTICLE

ECHOCARDIOGRAPHY FINDINGS IN HEMO DIALYSIS PATIENTS

Alam Sarfraz¹, Farya Moon¹, Adnan Wahid², Memoona Tofique¹¹Karachi Institute of Kidney Diseases, Karachi, Pakistan, ²National Institute of Cardiovascular Diseases, Karachi, Pakistan

Objectives: Echocardiographic assessment of patients with end-stage renal disease (ESRD) on maintenance hemodialysis (HD) is widely recommended and determining the spectrum of echocardiography abnormalities in these patients can have positive impact on the outcome. Therefore, in this study, our aim was to evaluate the echocardiographic findings in patients of ESRD on maintenance HD.

Methodology: In this cross-sectional study we included consecutive adult patients with ESRD on maintenance HD and transthoracic echocardiography findings were evaluated for structural and functional changes.

Results: A total of 120 patients were included in this study, patients were predominantly male (63.3%), and mean age of study sample was 46.5 ± 13.6 years with mean disease duration of 2.1 ± 1.8 years. Mean ejection fraction was $39.2 \pm 9.8\%$ with 70% (84) having moderate to severe left ventricular (LV) dysfunction. Dilated LV size was observed in 52.5% (63) and 15% (18) of the patients had LV hypertrophy. Higher grade (2 or greater) diastolic dysfunction was noted in 20% (24), pericardial effusion (moderate to large) in 5.8% (7), and 25 patients (20.8%) were found to have pulmonary hypertension. Moderate or severe mitral regurgitation (MR) was observed in 25% (30); moderate to severe tricuspid regurgitation (TR) in 21.7% (26), and mild aortic regurgitation was observed in one patient only.

Conclusion: Echocardiographic assessment revealed significant functional and structural alterations in patients with ESRD on maintenance HD. A moderate to severe LV dysfunction, MR, and TR along with a significant diastolic dysfunction and LV hypertrophy were some of the common echocardiography findings in these patients.

Keywords: end-stage renal disease, hemodialysis, echocardiography, Pakistan

Citation: Sarfraz A, Moon F, Wahid A, Tofique M. Echocardiography Findings in Hemo Dialysis Patients. Pak Heart J. 2022;55(04):331-335. DOI: <https://doi.org/10.47144/phj.v55i4.2333>

INTRODUCTION

Chronic kidney disease (CKD) is a growing global public health challenge associated with an increased risk of morbidity and mortality, especially premature death. The global prevalence of CKD is estimated to be 9.1% with approximately 700 million cases in the year 2017.¹ CKD may progress into renal failure which generally requires dialysis or even a renal transplant. However, CKD is more frequently associated with cardiovascular diseases (CVD) and it is interesting to note that mortality and morbidities due to CVD are more common than kidney failure among individuals with CKD.^{2,3} Both ischemic heart diseases (IHD) and congestive heart failure (CHF) are contributing to the higher rate of CVD-related morbidities and mortalities in these patients.² Prevalence of cardiac structural abnormalities are high among patients with end-stage renal disease (ESRD) on chronic hemodialysis (HD). Common structural abnormalities include left ventricular (LV) dysfunction, LV remodeling, and calcified valvular

sclerosis.⁴ the most frequent causes of death among patients on HD are sudden cardiac arrest or severe arrhythmias more than ischemic or cerebrovascular events.⁵

Ischemia in patients on dialysis is more likely to be secondary to the combined effects of left ventricular hypertrophy (LVH) and volume overload rather than large-vessel coronary artery disease (CAD), which may result in decreased oxygen supply due to small vessel CAD, which causes increased oxygen demand.^{6,7} Patients with CKD also have a high prevalence of remodeling of large arteries and arteriosclerosis.^{6,7} One important component of the treatment of HD patients is fluid balance, however, the occurrence of chronic hypervolemia in these patients can lead to increased arterial stiffness, LVH, CHF, hypertension, and increased adverse outcomes.⁸ Other predisposing factors for increased risk of adverse outcomes among HD patients are suggested to be intra- and inter dialytic shifts in metabolic parameters, electrolyte balance, and volume status due to the intermittent nature of renal replacement therapy and

inherent reduced capacity of patients with ESRD for uremic toxin excretion, electrolyte, and urinary fluid.^{9,10}

Early detection of abnormalities in cardiac structure and function may be helpful for appropriate management. Echocardiography is a commonly used non-invasive modality for identifying heart structural and functional abnormalities in hemodialysis patients. These include LVH, systolic and diastolic dysfunction of left ventricle (LV), left atrial (LA) and LV dilatation, right ventricular (RV) dysfunction, pulmonary hypertension, pericardial effusion and other associated valvular calcification, regurgitation and stenotic abnormalities.^{3,4,10-17} Echocardiographic assessment of ESRD patients is widely recommended method for the assessment of cardiovascular risks, pre-transplantation evaluation, and guidance of treatment.¹⁸ Determining the spectrum of echocardiographic abnormalities in these patients can change our vision in prevention of mortality in this group. Therefore, in this study, our aim was to evaluate the echocardiographic findings in patients of ESRD on maintenance HD.

METHODOLOGY

This cross-sectional study was conducted at the Karachi Institute of Kidney Disease (KIKD), Karachi, Pakistan between June 2021 and May 2022. Study was approved by the ethical review board of the hospital (KIKD) (KMC)-56/2020). Study was conducted according to the Declaration of Helsinki and verbal consent was obtained from all the participants. Inclusion criteria were, consecutive adult patients (≥ 18 years), patients with end-stage renal disease (ESRD) on maintenance hemodialysis (HD). Based on history patients on maintenance hemodialysis for less than one month (recent ESRD) or irregular (less than twice per week) HD frequency, and patients who refused to participate in the study were excluded from this study.

Transthoracic echocardiography was performed in all the patients after clinical examination and detailed history regarding risk factors, duration of disease, frequency and duration of hemodialysis sessions, and residual urine status. All echocardiography procedures were performed and interpreted by a consultant cardiologist and echocardiographic parameters included, ejection fraction (EF %), left ventricular (LV) dysfunction, LV size, left ventricular hypertrophy (LVH), diastolic dysfunction, pericardial effusion (PE), pulmonary hypertension (PAH), mitral regurgitation (MR), tricuspid regurgitation (TR), and aortic regurgitation (AR) grading. Demographic,

clinical, and echocardiographic parameters were collected on a predefined structured proforma.

M-mode and Doppler echocardiography in left decubitus position 2D was performed on a General Electric Vivid echocardiographic system with a 5S transthoracic probe. All the procedure were performed and interpreted by a single echo cardiographer who was blinded to the clinical status of patients. All echocardiographic parameters were measured and categorized as per the guidelines of the American Society of Echocardiography. Left ventricular dysfunction was categorized based on EF (%) as none: $\geq 52\%$ (males), $>54\%$ (females) mild: 40 to 52% (males), 40 to 54% (females), moderate: 40 to 30%, severe: $\leq 30\%$. Left atrial dilatation was considered for LA volume >34 ml/m².

Analysis of collected data was performed with the help of IBM SPSS version 19. Continuous demographic, clinical, and echocardiographic parameters, such as age (years), body mass index (kg/m²), duration of CKD (years), blood pressure (mmHg), and ejection fraction (%), were summarized as mean \pm standard deviation (SD). While, categorical demographic, clinical, and echocardiographic parameters were summarized with frequency (%). Patients were stratified into two groups based on duration of illness with cut-off of two years, and appropriate independent sample t-test or Chi-square /Likelihood ratio/Fisher's exact test were applied with 5% level of significance.

RESULTS

A total of 120 patients were included in this study, patients were pre-dominantly male (63.3%), and mean age of study sample was 46.5 ± 13.6 years with mean disease duration of 2.1 ± 1.8 years. Cause of renal failure was driven by hypertension in 46.7% (56) followed by diabetes in 29.2% (35), glomerulonephritis in 12.5% (15), and obstructive uropathy by 11.7% (14). A majority of the patients were having HD sessions at a frequency of thrice a week (60.8%) with four hour duration of each session (86.7%). Residual urine output was less than 100 ml / 24 hours for 66.7% (80) of the patients. Age of patient, cause of renal failure, frequency of HD sessions per week, and residual urine output were found to be associated with duration of CKD (Table 1). Mean EF was $39.2 \pm 9.8\%$ with 70% (84) having moderate to severe LV dysfunction. Dilated LV size was observed in 52.5% (63) and 15% (18) of the patients had LVH. Higher grade (2 or greater) diastolic dysfunction was noted in 20% (24), moderate to large pericardial effusion in 5.8% (7), and 25 patients (20.8%) were

found to have pulmonary hypertension. Moderate to Severe MR was observed in 25% (30), Moderate to Severe TR in 21.7% (26), and mild AR was observed

in one patient only. Poor LV ejection fraction and LV dysfunction were found to be associated with duration of diseases (Table 2).

Table 1: Dimorphic and clinical history of patients stratified by duration of illness

	Total	Duration of disease		P-value
		≤ 2 years	> 2 years	
Total	120	65.8% (79)	34.2% (41)	-
Gender				
Male	63.3% (76)	62% (49)	65.9% (27)	0.68c
Female	36.7% (44)	38% (30)	34.1% (14)	
Age (years)	46.5 ± 13.6	43.6 ± 13.9	51.9 ± 11.4	0.001t
Body mass index (kg/m²)	20.5 ± 2.6	20.3 ± 2.2	20.8 ± 3.2	0.363t
Cause of renal failure				
Hypertension	46.7% (56)	41.8% (33)	56.1% (23)	0.0011
Diabetes	29.2% (35)	25.3% (20)	36.6% (15)	
Glomerulonephritis	12.5% (15)	15.2% (12)	7.3% (3)	
Stone	11.7% (14)	17.7% (14)	0% (0)	
Duration of kidney disease (years)	2.1 ± 1.8	1.1 ± 0.6	4 ± 1.7	<0.001t
Hemodialysis sessions				
Twice a week	39.2% (47)	54.4% (43)	9.8% (4)	<0.001c
Thrice a week	60.8% (73)	45.6% (36)	90.2% (37)	
Duration of each session				
Three hours	13.3% (16)	16.5% (13)	7.3% (3)	0.163c
Four hours	86.7% (104)	83.5% (66)	92.7% (38)	
Residual urine				
Less than 100 ml / 24 hours	66.7% (80)	53.2% (42)	92.7% (38)	<0.001c
More than 100 ml / 24 hours	33.3% (40)	46.8% (37)	7.3% (3)	
Systolic blood pressure (mmHg)	138.7 ± 20.7	136.4 ± 18.1	143.1 ± 24.5	0.091t
Diastolic blood pressure (mmHg)	84.8 ± 9.5	85.4 ± 9.5	83.7 ± 9.6	0.372t

t=independent sample t-test, c=Chi-square, l=Likelihood ratio, f=Fisher's exact

Table 2: Echocardiographic findings of patients stratified by duration of illness

	Total	Duration of disease		P-value
		≤ 2 years	> 2 years	
Total	120	65.8% (79)	34.2% (41)	-
Ejection fraction (%)	39.2 ± 9.8	40.9 ± 9.2	35.8 ± 10.1	0.006t
Left ventricular dysfunction				
None	20.8% (25)	24.1% (19)	14.6% (6)	0.0151
Mild	9.2% (11)	11.4% (9)	4.9% (2)	
Moderate	26.7% (32)	31.6% (25)	17.1% (7)	
Severe	43.3% (52)	32.9% (26)	63.4% (26)	
Left ventricular hypertrophy	15% (18)	11.4% (9)	22% (9)	0.124c
Left ventricular size				
Normal	47.5% (57)	53.2% (42)	36.6% (15)	0.085c
Dilated	52.5% (63)	46.8% (37)	63.4% (26)	
Diastolic dysfunction	20% (24)	19% (15)	22% (9)	0.700c
Pericardial effusion	5.8% (7)	5.1% (4)	7.3% (3)	0.689f
Mitral regurgitation				
None	38.3% (46)	39.2% (31)	36.6% (15)	0.2191
Mild	36.7% (44)	39.2% (31)	31.7% (13)	
Moderate	17.5% (21)	17.7% (14)	17.1% (7)	
Severe	7.5% (9)	3.8% (3)	14.6% (6)	
Tricuspid regurgitation				
None	65.8% (79)	70.9% (56)	56.1% (23)	0.2211
Mild	12.5% (15)	12.7% (10)	12.2% (5)	

Moderate	15% (18)	12.7% (10)	19.5% (8)	
Severe	6.7% (8)	3.8% (3)	12.2% (5)	
Aortic regurgitation				
None	99.2% (119)	100% (79)	97.6% (40)	0.342f
Mild	0.8% (1)	0% (0)	2.4% (1)	
Pulmonary hypertension	20.8% (25)	22.8% (18)	17.1% (7)	0.465c

t=independent sample t-test, c=Chi-square, l=Likelihood ratio, f=Fisher's exact

DISCUSSION

Considering the significant association between CVD and CKD, in this study, we have evaluated structural and functional alterations on echocardiography in patients with ESRD on maintenance HD. We observed significant structural and functional changes in these patients such as nearly 70% of the patients were having moderate to severe LV dysfunction along with a significant number of subjects having diastolic dysfunction. Among other echocardiographic findings, LV hypertrophy, dilated LV, moderate or severe valvular abnormalities (MR and TR), and pericardial effusion were significantly noted. These findings not only confer the impact of ESRD and HD on CVD but also highlight the importance of regular cardiac assessment of these patients for better management and outcomes.

Similar to our study, Alam MZ et al.³ evaluated acute echocardiographic changes after 30 minutes of HD in a sample of ESRD patients from the Bangladeshi population. Study reported a significant reduction in LV function and significantly increased risk of LV failure and a significant incidence of wall motion abnormalities within 30 minutes of HD.³ Matsuo H et al.⁴ reported TTE assessment within 1 hour after HD in 315 ESRD patients and reported abnormal LV geometry in more than 88% with LVH in more than 66% along with normal LV filling pattern in only 3.4%. Also more than half of the patients were found to have calcification of either mitral or aortic valve.⁴ However, these studies have reported echocardiographic findings immediate (within in one hour) of hemodialysis, while, the present study has been done on patients on regular hemodialysis and echocardiographic studies have been done as a routine with no relation to timing after hemodialysis session. Hence differences in findings are expected on account of the acuity of findings.

A study by Hickson LJ et al.¹⁹ reported at least one echocardiographic (ECHO) criteria of structural heart disease (SHD) in 87% and at least three criteria in 54% of the HD patients. Study reported RV systolic dysfunction as an independent predictor of mortality with an adjusted hazard ratio of 1.68 [95% confidence interval: 1.35 - 2.07].¹⁹ Along with RV systolic dysfunction, impaired LV was also found to be

associated with adverse outcomes; hence, comprehensive echocardiographic assessment for structural heart diseases can have significant prognostic implications for patients with HD.¹⁹ In another study, LVH was reported to be associated with an increased risk of sudden cardiac death in HD patients.²⁰

A study by Jameel FA et al.¹⁴ which included maintenance HD patients from our local population also reported significant echocardiographic alterations with LV dysfunction in 31%, LVH in 55%, along with LV diastolic dysfunction in 47%, and incidence of LVH and LV dysfunction were reported to be significantly associated with hypertension.¹⁴ A similar study by Ahmed HA et al.²¹ reported LV systolic dysfunction in 36.3%, diastolic dysfunction in 53.3%, and LVH in 80% of patients with ESRD on maintenance HD.²¹

Echocardiographic variables can not only provide significant insights reading the progression of structural abnormalities but it can also provide significant insights into the volume status of HD patients. The minimum inferior vena cava diameter (ICVD) was reported to have good sensitivity (64%) and specificity (79%) in differentiating dehydrated and fluid overload patients before HD.¹¹ Similarly, the left atrial volume index was reported to be correlated with hydration status in these patients.¹⁵ Additionally, septal ratios of trans mitral flow velocity to annular velocity (E/e') has been reported to be a significant predictor of incidence of intradialytic hypotension.¹²

Even though this study was conducted at a large volume hospital in Karachi Pakistan but single-center coverage followed by a limited sample size remained the main limitation in the generalizability of study findings.

CONCLUSION

Echocardiographic assessment revealed significant functional and structural alterations in patients with ESRD on maintenance HD. Moderate to severe LV dysfunction, MR, and TR along with a significant diastolic dysfunction and LV hypertrophy were some of the common echocardiography findings in these patients. These findings not only confer the cardiac implications of ESRD and HD but also highlight the

importance of regular cardiac assessment of these patients for better management and outcomes.

AUTHORS' CONTRIBUTION

AS and FM: Concept and design, data acquisition, interpretation, drafting, final approval, and agree to be accountable for all aspects of the work. AW, and MT: Data acquisition, interpretation, drafting, final approval and agree to be accountable for all aspects of the work.

Conflict of interest: Authors declared no conflict of interest.

REFERENCES

- Cockwell P, Fisher LA. The global burden of chronic kidney disease. *Lancet*. 2020; 395(10225):662-4.
- Go AS, Chertow GM, Fan D, McCulloch CE, Hsu CY. Chronic kidney disease and the risks of death, cardiovascular events, and hospitalization. *N Engl J Med*. 2004;351(13):1296-305.
- Alam MZ, Hossain MZ. Echocardiographic assessment of cardiac dysfunction in maintenance hemodialysis patients. *Bangladesh Crit Care J*. 2017;5(2):97-100.
- Matsuo H, Dohi K, Machida H, Takeuchi H, Aoki T, Nishimura H, et al. Echocardiographic assessment of cardiac structural and functional abnormalities in patients with end-stage renal disease receiving chronic hemodialysis. *Circ J*. 2018;82(2):586-95.
- Charytan DM, Foley R, McCullough PA, Rogers JD, Zimetbaum P, Herzog CA, et al. Arrhythmia and sudden death in hemodialysis patients: protocol and baseline characteristics of the monitoring in dialysis study. *Clin J Am Soc Nephrol*. 2016;11(4):721-34.
- Aoki J, Ikari Y. Cardiovascular disease in patients with end-stage renal disease on hemodialysis. *Ann Vasc Dis*. 2017;10(4):327-37.
- Georgianos PI, Pikilidou MI, Liakopoulos V, Balaskas EV, Zebekakis PE. Arterial stiffness in end-stage renal disease-pathogenesis, clinical epidemiology, and therapeutic potentials. *Hypertens Res*. 2018;41(5):309-19.
- Abdelazim AS, Mahmoud BL, Ibrahim HG, Ahmed FA. Echocardiography Parameters during Long and Short Interdialytic Intervals in Hemodialysis Patients. *Egypt J Hosp Med*. 2022;87(1):1961-8.
- Canaud B, Chazot C, Koomans J, Collins A. Fluid and hemodynamic management in hemodialysis patients: challenges and opportunities. *Braz J Nephrol*. 2019;41:550-9.
- 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. *Am J Kidney Dis*. 2016;68(5):772-81.
- Sabaghian T, Hajibaratali B, Samavat S. Which echocardiographic parameter is a better marker of volume status in hemodialysis patients?. *Ren Fail*. 2016;38(10):1659-64.
- Chen CY, Yang NI, Lee CC, Hung MJ, Cherng WJ, Hsu HJ, et al. Dynamic Echocardiographic Assessments Reveal Septal E/e'Ratio as Independent Predictor of Intradialytic Hypotension in Maintenance for Hemodialysis Patients with Preserved Ejection Fraction. *Diagnostics*. 2021;11(12):2266.
- Nassiri AA, Hakemi MS, Safar-Pour R, Ahmadi A, Tohidi M, Kashani BS, et al. Association of serum intact fibroblast growth factor 23 with left ventricular mass and different echocardiographic findings in patients on hemodialysis. *J Transl Int Med*. 2016;4(3):135-41.
- Jameel FA, Junejo AM, ul ain Khan Q, Date S, Faraz A, Rizvi SH, et al. Echocardiographic changes in chronic kidney disease patients on maintenance hemodialysis. *Cureus*. 2020;12(7):e8969.
- Di Gioia MC, Gascuena R, Gallar P, Cobo G, Camacho R, Acosta N, et al. Echocardiographic findings in hemodialysis patients according to their state of hydration. *Nefrologia*. 2017;37(1):47-53.
- 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. *Am J Kidney Dis*. 2016;68(5):772-81.
- Kristensen CB, Steensgaard-Hansen F, Myhr KA, Løkkegaard NJ, Finsen SH, Hassager C, et al. Left ventricular mass assessment by 1-and 2-dimensional echocardiographic methods in hemodialysis patients: changes in left ventricular volume using echocardiography before and after a hemodialysis session. *Kidney Med*. 2020;2(5):578-88.
- Chiu DY, Green D, Abidin N, Sinha S, Kalra PA. Echocardiography in hemodialysis patients: uses and challenges. *Am J Kidney Dis*. 2014;64(5):804-16.
- Hickson LJ, Negrotto SM, Onuigbo M, Scott CG, Rule AD, Norby SM, et al. Echocardiography criteria for structural heart disease in patients with end-stage renal disease initiating hemodialysis. *J Am Coll Cardiol*. 2016;67(10):1173-82.
- Barberato SH, Bucharles SG, Barberato MF, Pecoits-Filho R. Association between clinical and Doppler echocardiographic parameters with sudden death in hemodialysis patients. *Arq Bras Cardiol*. 2016;107:124-30.
- Ahmed HA, Yassein YS, Zaki SA, Al Qersh AM, Fahim FS. Study of echocardiographic changes among adult patients on maintenance hemodialysis. *Menoufia Med J*. 2016;29(1):44-51.

Address for Correspondence:

Dr. Alam Sarfraz, Karachi Institute of Kidney Diseases, Karachi, Pakistan.

Email: ssa_alam2006@yahoo.com