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Echocardiographic findings in patient with chronic kidney disease

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Abstract

Background and Objectives: Chronic kidney disease (CKD) is a significant global health concern that is associated with an independent increase in the risk of cardiovascular disease (CVD). The presence and severity of CKD are closely linked to the progression of coronary atherosclerosis, ventricular hypertrophy, myocardial fibrosis, valvular calcification and abnormalities in the cardiac conduction system. The objective of this study was to assess the prevalence of systolic and diastolic dysfunction in patients with end-stage renal disease (ESRD) undergoing hemodialysis.

Materials and methods: A total of 100 patients diagnosed with ESRD were included in the study. Two-dimensional and M-mode echocardiography was performed to evaluate systolic and diastolic dysfunction. Clinical, biochemical, and radiological assessments were also conducted to diagnose CKD. Left ventricular ejection fraction (LVEF) and fractional shortening (FS) were utilized as measures of left ventricular (LV) systolic function. Diastolic function was determined by measuring the E/A ratio using spectral Doppler LV inflow velocity.

Results: In a study of 100 patients with end-stage renal disease (ESRD), hypertension was the leading cause of ESRD. Echocardiography revealed left ventricular hypertrophy in 72%, systolic dysfunction in 7%, decreased LVEF in 23%, diastolic dysfunction in 60%, RWMA in 13%, pericardial effusion in 13%, and valvular calcification in 5% of patients. Significant differences in LVH and E/A ratio were noted between hypertensive and normotensive groups.

Conclusion: Patients diagnosed with ESRD who also suffer from hypertension exhibited a greater incidence of both diastolic and systolic dysfunctions in comparison to individuals with normal blood pressure levels.

Key words: Chronic Kidney Failure, Ventricular Dysfunction, Renal Insufficiency, Atherosclerosis, Hypertrophy.

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Introduction

Chronic kidney disease (CKD) is recognized to be linked to an elevated susceptibility to cardiovascular mortality and morbidity [1]. While traditional risk factors for cardiovascular disease (CVD), such as diabetes, hypertension, obesity, and lipid abnormalities [2], contribute to this augmented risk, numerous studies have indicated that the association between CKD and cardiovascular mortality remains significant even after accounting for these factors [3–5]. A collaborative meta-analysis involving ten cohorts and a total of 266,975 patients revealed adjusted hazard ratios (HRs) for cardiovascular mortality of 1.11 (95% confidence interval [CI]: 0.93–1.32), 1.73 (95% CI: 1.49–2.00), and 3.08 (95% CI: 1.89–5.01) at estimated glomerular filtration rate (eGFR) levels of 60, 45, and 15 ml/min per 1.73 m^2, respectively [6].

Furthermore, the presence of albuminuria serves as another significant risk factor for unfavorable prognosis in individuals with CKD. Recent meta-analyses consistently demonstrate that both eGFR and albuminuria independently contribute to an increased risk of all-cause and cardiovascular mortality [7, 8].

The established cardiac abnormalities frequently observed in ESRD include an enlargement of the left ventricular (LV) cavity, thickening of the LV posterior wall and interventricular septum, impaired regional wall motion, reduced LV compliance, presence of pericardial effusion, and the occurrence of calcific/sclerotic valves [9]. The objective of this study was to determine the prevalence of both systolic and diastolic dysfunctions among patients with ESRD undergoing hemodialysis.

Material & methods

The study encompassed a total of 100 individuals diagnosed with CKD and ESRD of any etiology. Inclusion criteria involved individuals with a CKD duration exceeding three months, abnormal ultrasound findings indicative of kidney disease, and reduced creatinine clearance, signifying chronic kidney disease. For individuals to be categorized as ESRD, their glomerular filtration rate (GFR) needed to be below 15 ml/min per 1.73m^2 according to the Cockcroft Gault equation, and they must have been undergoing hemodialysis treatment. The study followed ethical guidelines [10].

Patients with pre-existing cardiac conditions such as rheumatic heart disease, congenital heart disease, other cardiovascular diseases including myocarditis resulting from infective causes, and primary heart muscle diseases such as cardiomyopathies were excluded from the study. All participants underwent clinical evaluation for cardiac involvement, and the following investigations were conducted: complete hemogram, renal function test, serum electrolytes, blood glucose level, lipid profile, electrocardiogram (ECG), chest X-ray, and 2-D echocardiography.

2D echocardiography machine was utilized in this study, employing a 3.5 MHz transducer probe. Both two-dimensional echocardiography and M-mode echocardiography were performed. M-mode recordings were taken perpendicular to the long axis of the left ventricle and through the center, at the level of the papillary muscles, to obtain standard measurements of systolic and diastolic wall thickness and chamber dimensions. Left ventricular ejection fraction (LVEF) and fractional shortening (FS) were utilized as measures of left ventricular systolic function.

For the assessment of diastolic function, the E/A ratio was measured using special Doppler inflow velocity. The E/A ratio represent the peak early diastolic velocity (E) and the peak atrial filling velocity (A) of the left ventricle across the mitral valve. A E/A ratio less than 0.75 or greater than 1.8 was considered indicative of diastolic dysfunction. Left ventricular

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hypertrophy (LVH) was diagnosed when the interventricular septum thickness or the left ventricular posterior wall thickness was equal to or greater than 12 mm.
The statistical analysis was conducted using SPSS software version 20. The chi-square test was employed for data analysis. A significance level of $p < 0.05$ was considered statistically significant.

Results

Among the sample of 100 patients under investigation, 65 were males and 35 were females. Notably, the largest proportion of patients fell within the age range of 51 to 60 years, comprising 39 individuals. The mean age of the patients diagnosed with ESRD was determined to be 54.41 ± 11.97. The primary causative factor attributed to the occurrence of ESRD was hypertension, accounting for approximately 37.5% of the cases. Other notable causes included diabetes (21.21%), diabetes concomitant with hypertension (9.6%), chronic glomerulonephritis (8.9%), polycystic kidney disease (6.9%), obstructive uropathy (5.9%), analgesic nephropathy (3.1%), and cases where the etiology remained unidentified (7.2%).
A comprehensive analysis was conducted on various parameters obtained from echocardiography. Specifically, the following parameters were thoroughly examined: left ventricular internal diameter during systole and diastole, interventricular septum diameter during systole, left ventricular posterior wall diameter, E/A ratio, fractional shortening (FS), and left ventricular ejection fraction (LVEF). These parameters and their corresponding data are presented in Tables 1 and 2 for detailed evaluation.

Table 1: Echocardiographic parameters in study population.

Echocardiography Parameter	Mean± SD
LV internal diameter in diastole (in mm)	45.55 ± 6.03
LV internal diameter in systole (in mm)	29.8 ± 6.02
Interventricular septum diameter during systole (in mm)	12.2 ± 1.71
LV posterior wall diameter (in mm)	12.0 ± 1.81
LA diameter (in mm)	33.01 ± 4.11
FS (%)	34.06 ± 8.41
LV EF (%)	54.91 ± 9.62
E' peak (in mm/sec)	73.47 ± 16.21
A' peak (in mm/sec)	83.8 ± 24.5
E/A ratio	0.95 ± 0.35

Table 2: Echocardiographic findingsin study population.

Echocardiographic Finding	Frequency	Percentage (%)
LV hypertrophy	72	72
FS (< 25%)	7	7
LVEF (< 50%)	23	23
E/A ratio (< 0.75 or >1.8)	60	60
Regional wall motion abnormality	13	13
Pericardial effusion (< 10 mm)	13	13
Valvular calcification	5	5
Mitral regurgitation	7	7

The patients were classified into two distinct groups based on their serum cholesterol levels: the first group consisted of individuals with serum cholesterol levels exceeding 200 mg/dL, while the second group comprised patients with serum cholesterol levels below 200 mg/dL.

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The correlation between the findings obtained from the 2D-echo examination and the serum cholesterol levels was analyzed and the results are presented in Table 3.

Table 3: Correlation of echocardiographic findings and total cholesterol in study cases.

Echocardiographic finding	TC < 200 mg/dL (N = 38)		TC > 200 mg/dL(N = 62)		P-Value
	n	%	n	%	
LVH					
No	14	36.84	18	29.03	0.37
Yes	24	63.16	44	70.97	
Decreased EF					
No	28	73.68	39	62.90	0.36
Yes	10	26.32	23	37.10	
Decreased FS					
No	29	76.32	47	75.81	0.09
Yes	9	23.68	15	24.19	
Abnormal E / A ratio					
No	22	57.89	19	30.65	< 0.05
Yes	16	42.11	43	69.35	
RWMA					
No	32	84.21	43	69.35	< 0.05
Yes	6	15.79	19	30.65	
Pericardial Effusion					
No	30	78.95	42	67.74	0.34
Yes	8	21.05	20	32.26	

In this study, hypertension was defined as having a blood pressure reading above 140/90 mmHg. Based on this criterion, all patients were divided into two groups: hypertensive and normotensive. The aim was to compare the findings obtained from the 2D-echo examination between these two groups of patients with end-stage renal disease (ESRD). The comparative analysis is presented in Table 4.

Table 4: Correlation of echocardiographic findings and blood pressure in study cases

Echocardiographic finding	Normotensive (N = 30)		Hypertensive (N = 70)		p Value
	n	%	n	%	
LVH					
No	17	56.67	8	11.11	< 0.05
Yes	13	43.33	62	86.11	
Decreased EF					
No	28	93.33	50	69.44	0.11
Yes	3	10.00	20	27.78	
Decreased FS					
No	28	93.33	65	90.28	0.89
Yes	2	6.67	5	6.94	
Abnormal E / A ratio					
No	18	60.00	19	26.39	< 0.05
Yes	12	40.00	51	70.83	
RWMA					
No	27	90.00	59	81.94	0.3
Yes	3	10.00	11	15.28	
Pericardial Effusion					
No	25	83.33	61	84.72	0.91

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Yes	5	16.67	9	12.50	

Discussion

Premature cardiovascular disease poses a significant threat to the well-being and survival of individuals with chronic kidney disease (CKD). The occurrence of premature atherosclerotic coronary disease in this population is influenced by multiple risk factors, prominently including dyslipidemia and oxidative stress. Patients with CKD exhibit four primary structural abnormalities in their hearts: left ventricular hypertrophy, expansion of the nonvascular cardiac interstitium leading to inter-myocardiocytic fibrosis, alterations in vascular architecture, and myocardial calcification. These abnormalities collectively contribute to both systolic and diastolic left ventricular dysfunction, increasing the susceptibility to symptomatic heart failure. Notably, symptomatic heart failure serves as a risk factor for premature mortality in this patient population.

In this study, echocardiography revealed left ventricular hypertrophy in 72%, systolic dysfunction in 7%, decreased LVEF in 23%, diastolic dysfunction in 60%, RWMA in 13%, pericardial effusion in 13%, and valvular calcification in 5% of patients. Significant differences in LVH and E/A ratio were noted between hypertensive and normotensive groups. In a study conducted by Robert N. Foley et al. in 1995, it was discovered that abnormalities pertaining to the structure and functioning of the left ventricle were highly prevalent based on the findings obtained from baseline echocardiography [11]. According to a study conducted by NP Singh et al. in 2000, the prevalence of LVH was found to be 76.92% among patients with CKD. Additionally, diastolic dysfunction was observed in 72% of the patients. However, the study did not report the presence of systolic dysfunction in CKD patients [12].

The findings of Zoccali et al. in 2000 revealed that 77% of haemodialysis patients exhibited left ventricular hypertrophy (LVH), and 22% of these patients demonstrated systolic dysfunction as determined by left ventricular ejection fraction (LVEF) measurement [13]. Similarly, S. Agarwal et al. in 2003 observed diastolic dysfunction in 60% of patients and systolic dysfunction in 15% of patients. These findings align with the results obtained in the present study, thus establishing consistency across multiple studies in terms of the prevalence of LVH, diastolic dysfunction, and systolic dysfunction among patients with the respective conditions [14].

In the present study, a statistically significant association was observed between the findings of 2D-Echo and lipid profile in patients. The proportion of patients with abnormal E/A ratio was nearly doubled, and the presence of regional wall motion abnormalities (RWMA) was six times higher in the group with elevated serum total cholesterol compared to the group with normal serum cholesterol. These findings indicate that hyperlipidemia increases the risk of cardiovascular involvement in patients with end-stage renal disease (ESRD). These results align with similar findings reported in previous studies [15, 16].

A statistically significant association was observed between the findings of 2D-Echo in patients with hypertension compared to the normotensive group, specifically in relation to parameters such as left LVH and abnormal E/A ratio. Juan M. et al. [17] in 1998 found statistically significant differences in E/A ratio, FS, and LVEF between hypertensive and normotensive patients. Patrick S et al. [18] in 1999 demonstrated that an increase in mean arterial blood pressure was associated with an increase in LVH among ESRD patients. SA Kale et al. [19] in 2001 identified hypertension as an important risk factor for LVH, diastolic dysfunction, and systolic dysfunction. They found that systolic, diastolic, and mean blood pressure were each significantly associated with LV disease.

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Various imaging modalities, such as echocardiography, non-contrast-enhanced magnetic resonance imaging (MRI), nuclear myocardial perfusion imaging, and metabolic imaging, provide diverse options for evaluating obstructive coronary artery disease (CAD) and cardiomyopathy in advanced CKD patients. Importantly, these imaging techniques can be utilized without the requirement of nephrotoxic contrast agents, ensuring the safety and well-being of individuals with compromised kidney function [20].

Conclusion

Echocardiographic abnormalities are prevalent even in the early stages of CKD. The evaluation of cardiac structures, particularly the left ventricle and left atrium, through echocardiography can offer valuable information for the management of patients across the entire spectrum of CKD. This underscores the importance of incorporating echocardiographic assessments into the care of CKD patients to identify and monitor cardiac abnormalities early on.

Conflicts of interest

None

Source of funding

None

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