Original Article

Cardiac Status Of Patients On Maintenance Haemodialysis – A Prospective Study

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Abstract

Background: An understanding of the cardiovascular effects of patients with chronic kidney diseases on maintenance haemodialysis is essential.

Objectives: The objectives of the present study were to understand the cardiovascular changes and complications in patients with chronic kidney disease on maintenance haemodialysis.

Methods: This was a single centre non-randomized prospective observational study conducted at Department of General Medicine, Government Villupuram Medical College, Villupuram, Tamil Nadu, India between November 2019, and November 2021. The study enrolled hundred adult inpatients admitted with CKD on maintenance haemodialysis consecutively – a non-probability convenient sampling technique. After enrolment, the patients were followed up with ECG, chest X-ray and echocardiography at 3 months and 6 months along with detailed clinical and systemic examination.

Results: Of the included 100 patients, two died during the course of the study and none were lost to follow up. The mean (SD) age of the patients was 42.4 (10.1) with male preponderance in all age groups. The male to female ratio was 2.6:1. Pedal oedema and decreased urine output were the commonest symptoms (>90% cases) with a symptom duration ranging between 4 months and 5 years. The present study did not show a statistically significant decline or improvement in haemoglobin during the course of study ($p>0.05$). The values of blood urea and serum creatinine had a statistically significant reduction at 3 and 6 months compared to baseline ($p<0.001$). The mean (SD) ejection fraction was 44.3% at the end of 6 months. Majority (83.6%) had systolic dysfunction at 6 months. Left ventricular hypertrophy with echocardiography and cardiomegaly diagnosed with X-ray was found in 53.1% and 35.7% at the end of 6 months. The commonest ECG change noted was LVH (41.8%) followed by sinus tachycardia (19.4%).

Conclusion: The findings of the present study will cater to early diagnosis, prompt care and prevention of further complications of cardiovascular effects of patients with chronic kidney diseases on maintenance haemodialysis which will arise during the course of the disease process.

Key words: Chronic Kidney Disease, Cardiovascular effects, Haemodialysis, Left Ventricular Hypertrophy

INTRODUCTION

The role of kidneys in maintaining homeostasis in a normal healthy individual cannot be overstated. It is the primary organ of excretion and engages in filtration of extracellular fluid and renders it free from toxins and metabolic waste products.[1] It also has a pivotal role in maintaining the plasma osmolarity by modulating the amount of water, solutes, and electrolytes in the blood.[2, 3] It plays a key role in the acid base balance and also serves important endocrine functions by producing erythropoietin which ensures adequate RBC production.[4] It also produces renin which is responsible for long term control of Blood pressure and also activates Vitamin D to its active form thereby maintaining calcium homeostasis.[5, 6] Chronic kidney disease (CKD) is a heterogenous condition characterised by irreversible loss of kidney function resulting from functional and or structural nephron loss.[7] However the implication of the disease process is not confined to the renal system alone but to almost all systems in the body.[8, 9]

The progressive loss of renal function causes a multifaceted decline in the normal functions it performs resulting in significant dysfunction in multiple systems. The evolution of CKD can be subdivided into various stages according to the decline in glomerular filtration rate, ultimately leading to end stage renal disease where the patient has to be dependent on permanent renal replacement therapy for maintenance of health.[10] This puts significant impact on the quality of life and the life expectancy of the patients. Chronic kidney disease is associated with premature mortality, decreased quality of life, and increased health-care expenditures.[11-14]

The prevalence of chronic kidney disease continues to rise worldwide.[9] However, many of these patients develop cardiovascular diseases and die prematurely. Even on regular haemodialysis the course of the disease is relentless, and many succumb to cardiovascular complications during the course of the disease. Cardiovascular diseases (CVD) are a major cause of death in CKD patients as they have an accelerated rate of atherosclerosis. The age adjusted mortality indices shows a risk of as high as 30 times chances of death in CKDs.[14] Accelerated rates of atherosclerosis, coronary artery disease, cerebrovascular accidents, cardiomyopathy leading to both systolic and diastolic dysfunctions, accelerated hypertension, recurrent pulmonary oedema, multiorgan dysfunction due to uraemia, severe anemia are all encountered during the progression of chronic kidney disease which both impairs the quality of life and cause premature death.[15-17] Haemodialysis by itself causes a dynamic impact in the cardiovascular mechanics due to multiple factors both mechanical and operational.[18, 19] Most of these changes are poorly studied and there is a paucity of scientific literature pertaining these aspects. A sound understanding of the cardiovascular effects of patients with chronic kidney diseases on maintenance haemodialysis will cater to early diagnosis, prompt care and prevention of further complication of these events which will arise during the course of the disease process.

Against this background the present aims at understanding the cardiovascular changes and complications in patients with chronic kidney disease on maintenance haemodialysis. The specific objectives were to monitor the cardiac status of patients with CKD after the initiation of haemodialysis; to understand the dynamics of disease progression and evolution in terms of the cardiovascular adverse effects in CKD patients on maintenance haemodialysis.

MATERIALS AND METHODS

The present was a single centre non-randomized prospective observational study conducted at Department of General Medicine, Government Villupuram Medical College, Villupuram, Tamil Nadu, India between November 2019 and November 2021. The study enrolled hundred adult inpatient admitted with CKD on maintenance haemodialysis consecutively – a non-probability convenient sampling technique. The patients with CKD of various aetiologies evidenced by raised blood urea nitrogen and serum creatinine, corroborated with sonological findings of lost corticomedullary differentiation, type 2 or type 3 parenchymal changes or patients with bilateral contracted kidneys were included. Patients with Autosomal Dominant Polycystic Kidney Disease and Obstructive Nephropathy were also included in the study. However, patients with known history of congenital, valvular, ischemic heart diseases (electrocardiography (ECG), echocardiography and chest X-ray was one); on antiplatelets, anticoagulant or anti-failure drugs; and with a history of cardiac intervention procedures or cardiac surgeries were excluded.

The study was approved by Institute Ethics Committee, Government Villupuram Medical College, Villupuram, Tamil Nadu, India. The content of Participant Information Sheet (PIS) in local language was provided to the study subjects and contents were read to them in their own language to their satisfaction. The study subjects were enrolled in the study after obtaining written informed consent. After the induction of dialysis, the patients were followed up with ECG, chest X-ray and echocardiography at 3 months and 6 months of commencement of the study. a detailed clinical examination was done, and vital signs were recorded, Systemic examination was performed at the beginning of the study and at each point of assessment. All patients were treated with optimal treatment as per institutional and national protocols including diuretics, antihypertensives, hematinics and maintenance haemodialysis.

The data were entered in Microsoft Excel datasheet and analysed using the STATA 16.0 version [Statistical Software: Release 14. College Station, TX: Stata Corp LP]. Descriptive analysis was precented using numbers (frequencies), percentages, measures of central tendency (mean) and dispersion (standard deviation). Tables and graphs were made as appropriate. Tests of association was performed and p value <0.05 was considered statistically significant.

RESULTS

The present study enrolled 100 adult inpatient admitted with CKD on maintenance haemodialysis. Two patients died during the course of the study and none were lost to follow up during the study duration. The mean (SD) age of the patients included in the study was 42.4 (10.1) varying between 16 and 68 years. Majority of the patients were between 21 and 40 years of age (54.0%), with male preponderance in all groups. Overall, 72.0% of the included patients were males and 28.0% were females. The male to female ratio was 2.6:1.

Pedal oedema and decreased urine output were the commonest symptoms (>90% cases) followed by easy fatiguability and shortness of breath on exertion (>70% cases). Chest pain and palpitations were less common presenting symptoms and were often associated with the other symptoms. The CKD patients who were initiated on haemodialysis had symptoms of the disease ranging in duration from 4 months to 5 years. Many patients were initially managed conservatively and were initiated on haemodialysis at Stage 5 of the disease when conservative treatment were no longer effective. One in four patients (24.0%) were diagnosed as CKD when they presented to the hospital in an acute setting with either pulmonary oedema or severe metabolic acidosis.

The mean (SD) haemoglobin level at the start of study was 7.12g% (1.64) ranging between 4.1 to 10.1g%. The patients were given regular iron supplements and erythropoietin during the course of 6 months and the mean haemoglobin at the

end of 3 months and 6 months was 7.54g% (1.18) and 7.19g% (0.98) respectively. There was no significant decline or improvement in haemoglobin during the course of study.

At the start of haemodialysis, the blood urea of the patients were very high ranging between 89 and 261mg/dl with a mean value of 148.32mg/dl. However, with adequate dialysis there was a steady decline in urea levels in patients who were on HD. Serum Creatinine is a commonly used endogenous marker for the assessment of glomerular function as it is almost totally excreted by the kidneys. The mean creatinine was 10.0g/dl at the time of initiation of dialysis in the present study, with a range of 7.4 to 12.4 mg/dl. The mean values of creatinine fell to 2.96mg/d at the end of 3 months and 3.08mg/dl at the end of 6 months. The values of blood urea and serum creatinine had a statistically significant reduction at 3 and 6 months compared to baseline ($p<0.001$). Majority of our patients were stable and maintaining a near normal quality of life in terms of being able to perform their activities of daily living without support.

Majority of the CKD patients (96.0%) were hypertensive and were on regular antihypertensive drugs. The mean (SD) systolic BP at the beginning of HD, 3 and 6 months was 150.2mmHg (15.34), 139.3mmHg (14.9) and 137.9mmHg (15.3) respectively. The mean decrease in the diastolic BP was of a lesser magnitude and the mean (SD) diastolic BP at the start of the study was 98.08mmHg (8.95), ranging between 76 and 118mmHg. The administration of regular HD along with adequate pharmacotherapy resulted in a better control of blood pressure in our patients.

The mean (SD) ejection fraction was 53.2% (5.88) at the start of haemodialysis which decreased to 48.8% and 44.3% at the end of 3 months and 6 months respectively ($p<0.001$). The least EF recorded at the end of 6 months of HD was 27%. More than half (57.0%) the patients had systolic dysfunction at the start of the study which increased to 73.0% and 83.6% at the end of 3 months and 6 months respectively. The prevalence of moderate LVSD doubled and severe LVSD quadrupled at the end of 6 months in our study group. The level of haemoglobin had a direct correlation with the ejection fraction of the patients which indicated that anemia is one of the important factor that can be attributed to the systolic dysfunction ($p<0.001$).

Left ventricular hypertrophy, a prominent feature of CKD was identified with echocardiography 24.0% patients which subsequently increased to 53.1% at the end of 6 months. The proportion of patients with cardiomegaly diagnosed with X-ray was 19.0%. It increased to 27.0% and 35.7% at the end of 3 and 6 months. Pericardial effusion was seen in 8.0% of cases at the start of the study; reduced to 5 cases at 3 months and 1 case at 6 months. All patients with pericardial effusion were managed with regular heparin free dialysis till the pericardial effusion resolved. Valvular lesions are fairly common in patients in CKD especially in the later stages. Our study showed a prevalence of 44.9% at the end of 6 months of HD. Mitral regurgitation was the commonest valvular lesion encountered in CKD patients which was seen in 18.0% cases increasing to 34.7% at the end of 6 months.

The commonest ECG change noted was LVH (41.8%) followed by sinus tachycardia (19.4%). Right atrial enlargement and left atrial enlargement was seen in 17.3% and 15.3% cases respectively. ST/T wave changes included T wave inversions and ST segment depressions and was seen only in 7 cases. Wide QRS complexes were seen in 7 cases which had bundle branch blocks. Most of these changes were representative of the background coronary artery diseases and accelerated atherosclerosis in these patients.

DISCUSSION

Chronic kidney disease is a spectrum of pathophysiologic processes resulting in persistent abnormality in kidney structure or function causing progressive decline in glomerular filtration rate lasting for more than three months, irrespective of clinical diagnosis.[20, 21] The primary role of kidney is to excrete the metabolic waste products and maintain a milieu of metabolic homeostasis.[22] The kidneys produce urine which is the medium of excretion of the waste products. Urine production is performed by nephrons which are the structural and functional units of kidneys and is micro modulated by three separate processes namely glomerular filtration, tubular reabsorption, and tubular secretion.[23, 24] However, CKD results in decline in the number of functioning nephrons and thereby resulting in the pathological alteration of these processes. The development of CKD has profound effect on the normal physiology and causes widespread pathological effects.[17] Against this background, this study was undertaken to evaluate the cardiovascular impact and effects on patients with CKD on maintenance haemodialysis.

A total of hundred patients were enrolled in the study who were newly initiated on haemodialysis. Baseline cardiac parameters were recorded followed by reassessment at 3 and 6 months. There was an overall male preponderance in the study group with the male female ratio of 2.6:1. During the course of the study, two patients expired. The mean age of the study group was 42.4 years, majority were between 21 and 40 years of age. It reflects the significant number of young onset CKD in our population. SEEK study (Screening and Early Evaluation of Kidney disease) has previously reported the mean (SD) age of CKD among the screened population to be 45.2 (15.2) years with a higher male preponderance.[25, 26]

Our study population had symptoms of CKD ranging in duration from 4 months to 5 years. Pedal oedema and decreased urine output were the commonest symptoms (>90% cases). Easy fatiguability and shortness of breath on exertion were

also reported (>70% cases). All these symptoms were multifactorial and reflects the intravascular volume overload, declining cardiovascular function, anemia and other associated factors.

The mean haemoglobin (Hb) in our study group at the start of study was 7.12 g/dl which remained fairly constant over the 6 months study duration. This highlights the widespread prevalence of severe anemia among patients with ESKD. Anemia in CKD is multifactorial and mainly due to decreased production of erythropoietin by the kidneys, decreased RBC survival in uremic environment, persistent inflammation causing anemia of chronic disease. Patients with CKD also have increased iron losses, estimated approximately at 1–3 g per year in haemodialysis patients, due to chronic bleeding from uraemia-associated platelet dysfunction, frequent phlebotomy, and blood trapping in the dialysis apparatus is also a commonly encountered cause.[27, 28]

Our study correlates with the findings of Foley et al. The study identified that low Hb was an independent factor associated with risk of left ventricular dilatation and cardiac failure as we had a high prevalence of patients with LVH and cardiomegaly in our study group.[29] Various systematic reviews and meta-analyses have suggested that normalising the haemoglobin has a higher incidence of hypertension and deaths. As per previous literature, the target for Hb correction in patients with CKD is 10-12 g/dl without the higher incidences of untoward outcomes.[30, 31]

Blood urea and serum creatinine was considerably elevated at the start of dialysis which gradually declined to nadir at reassessment and our patients remained largely symptom free with a near normal quality of life. There was a significant decrease in mean systolic BP from 150 mmHg to 138 mmHg in the study group but only a minimal decrease in the mean diastolic BP from 98 mmHg to 96 mmHg at the end of 6 months which reflects the capability of haemodialysis to remove the volume load and decongest the cardiovascular system but its limited effects on total peripheral resistance.[32, 33]

Echocardiography monitoring of the patients revealed a significant decrease in ejection fraction over the study duration, increase in the incidence of systolic and diastolic dysfunction along with increased incidence of valvular lesions wherein mitral regurgitation was the commonest valvular lesion encountered. Mitral regurgitation was seen in 18.0% cases which increased to 34.7% cases at the end of six months. Left sided lesions were more common which shows the effect of chronic systemic hypertension and degenerative valvular lesions. Regurgitant lesions especially tricuspid regurgitation is generally reflective of the volume status and is mostly functional and secondary to fluid overload. Our study correlates with previous literature on the incidence of valvular diseases by KDIGO in the relative incidence of valvular lesions in ESKD.[34] Pericardial effusion was seen in 8.0% of cases at the start of the study. There was a significant decrease in incidence of pericardial effusion with one patient at the end of 6 months. Pericardial effusions are seen in patients who are inadequately dialysed and was seen in relatively few patients in our study group.[35]

Left ventricular hypertrophy was commonly seen in CKD and is reflective of the altered hemodynamics and systemic hypertension which was identified with echocardiography and radiologically with cardiomegaly in the form of increased cardiothoracic ratio. LVH was identified in 53.1% of patients compared to 24.0% at the beginning of study. Cardiomegaly was seen in 35.7% cases at the end of the study. Echocardiography has higher sensitivity than chest X-ray in identifying cardiomegaly and identifying it at an earlier in the course of disease.[36, 37] Electrocardiography also demonstrated significant features of cardiac disease in patients with CKD. Chamber enlargement was also seen in many patients which reflected the degenerative and hypertensive changes in left heart and volume overload in right heart.[38, 39]

The present study is not without limitations. The cases of CKD were followed up to a period of six months. However, the cardiovascular changes evolve over long term and progressively worsen with time. Therefore, long term studies can be undertaken to better understand the pathophysiology and changes that happen in CKD patients treated with Haemodialysis.

To conclude, the present study has revealed a high proportion of patients with stage five CKD on haemodialysis were of young and middle age groups. Therefore, further studies should be undertaken to identify the causes of young onset CKD in Indian population and preventive measures should be undertaken.

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Table 1: Distribution of demographic variables and symptom profile among CKD patients on haemodialysis

Variables		Number (n)	Percentage (%)
Age (in years)	Less than 20	4	4.0
	21 to 40	54	54.0
	41 to 60	26	26.0
	More than 60	16	16.0
Gender	Males	72	72.0
	Females	28	28.0
Symptoms*	Shortness of breath	72	72.0
	Decreased urine output	95	95.0
	Easy fatiguability	76	76.0
	Pedal oedema	93	93.0
	Chest pain	18	18.0
	Palpitations	13	13.0
Duration of symptoms	Less than 6 months	29	29.0
	6 months to 1 year	35	35.0
	More than 1 year	36	36.0
*Total may not round up to 100, as participants had multiple co-existing symptoms			

Table 2: Distribution of lab and radiological investigations at the start, three months, and six months of haemodialysis

Variable	At the start of HD Mean (SD) or n (%)	At 3 months Mean (SD) or n (%)	At 6 months[#] Mean (SD) or n (%)
Haemoglobin level	7.12 (1.64)	7.54 (1.18)	7.19 (0.98)
Blood urea	148.32 (48.75)	47.16 (10.79)	41.16 (6.72)
Serum creatinine	10.01 (1.50)	2.96 (0.76)	3.08 (0.82)
SBP	150.2 (15.34)	139.28 (10.30)	137.96 (10.79)
DBP	98.08 (8.95)	96.16 (8.89)	96.0 (8.85)
Ejection fraction	53.2 (5.88)	48.76 (5.62)	44.29 (7.11)
Systolic dysfunction*	57 (57.0)	73 (73.0)	82 (83.7)
LVH (Echocardiography)	24 (24.0)	38 (38.0)	52 (53.1)
Cardiomegaly (X-ray chest)	19 (19.0)	27 (27.0)	35 (35.7)
Pericardial effusion	8 (8.0)	5 (5.0)	1 (1.0)
*Includes mild, moderate, and severe cases [#]Total patients evaluated were 98			

Figure 1: Prevalence of systolic dysfunction among CKD patients on haemodialysis

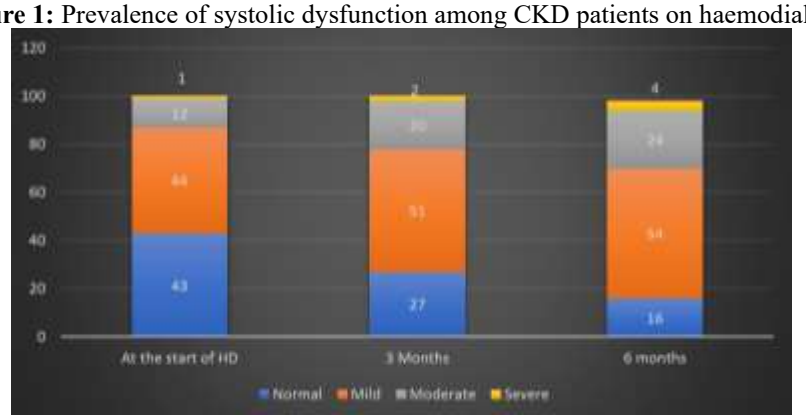

Table 3: Distribution of valvular diseases among CKD patients on haemodialysis

Valvular diseases	At the start of HD n (%)	At 3 months n (%)	At 6 months[#] n (%)
Mitral regurgitation	18 (18.0)	25 (25.0)	34 (34.7)
Mitral stenosis	2 (2.0)	4 (4.0)	5 (5.1)
Tricuspid regurgitation	8 (8.0)	13 (13.0)	16 (16.3)
Aortic stenosis	4 (4.0)	7 (7.0)	11 (11.2)
Aortic regurgitation	4 (4.0)	12 (12.0)	17 (17.3)
Number of cases with valvular lesions	21 (21.0)	32 (32.0)	44 (44.9)
[#]Total patients evaluated were 98			

Table 4: Distribution of ECG changes among CKD patients on haemodialysis

ECG changes	At the start of HD n (%)	At 3 months n (%)	At 6 months[#] n (%)
Tachycardia	22 (22.0)	18 (18.0)	19 (19.4)
Left atrial enlargement	4 (4.0)	8 (8.0)	15 (15.3)
Right atrial enlargement	7 (7.0)	9 (9.0)	17 (17.3)
Wide QRS	4 (4.0)	5 (5.0)	7 (7.1)
LV hypertrophy	21 (21.0)	29 (29.0)	41 (41.8)
ST segment changes	4 (4.0)	6 (6.0)	7 (7.1)
[#]Total patients evaluated were 98			