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Cardiac Evaluation of Chronic Kidney Disease Patients under Maintenance Hemodialysis

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ABSTRACT

Introduction: Chronic kidney disease (CKD) patients are at increased risk of morbidity and mortality because of their native disease progression. Accumulation of other atherosclerotic risk factors associated with CKD multiplies their risks. This study aimed to evaluate cardiac structural and functional abnormalities in CKD patients undergoing Maintenance Hemodialysis (MHD) using Electrocardiography (ECG) and Echocardiography (Echo).

Method: It was a prospective cross-sectional study containing all CKD patients undergoing MHD at Pokhara Academy of Health Sciences, Pokhara, Nepal was conducted between August 2020 to December 2020. All the relevant data were entered in Statistical Package for Social Science (SPSS) for analysis.

Results: There was a total of 115 patients with a male: female ratio of 1.8:1and a mean age of 47.25 ± 15.20years. The mean duration of dialysis was 36months and hypertension was the prime risk factor. Common ECG abnormalities were left ventricular hypertrophy, left ventricular strain pattern and poor R wave progression. Common Echo abnormalities were left ventricular diastolic dysfunction, left ventricular hypertrophy and regurgitation. Left ventricular systolic dysfunction was present in 20% of the patients.

Conclusion: A spectrum of structural and functional cardiac abnormalities is common in CKD patients undergoing MHD. Early measures should be adopted to mitigate the risk.

Keywords: *Echocardiography; Electrocardiography; Renal Dialysis*

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INTRODUCTION

Cardiovascular disease (CVD) is the leading cause of increased morbidity and mortality in Chronic Kidney Disease (CKD) patients. International registries document that cardiac disease accounts for 40% of deaths in dialysis patients.[1,2] As traditional risk factors for CVD such as hypertension, dyslipidemia and diabetes are highly prevalent in CKD patients, they are more prone to CVD and its consequences.[3-5] Alarmingly, CKD themselves impart direct adverse effects on the cardiovascular system. An echocardiogram gauges ventricular mass & volume, defines the geometric pattern, quantifies systolic function, generates information regarding ventricular relaxation and dynamics of heart filling (diastolic function) as well as depicts abnormalities in cardiac valves and the pericardium.[6,7] Similarly, an electrocardiogram can assess arrhythmia, conduction abnormalities, left ventricular hypertrophy, and ischemia and defines the cardiac axis which decently supplements cardiovascular assessment.[8,9]

A composite cardiac evaluation by utilizing electrocardiography as well as echocardiography in CKD patients undergoing maintenance hemodialysis has not been documented in our country to date. However, few recent studies employing only echocardiography have been reported. [10-12] Hence, the objective of this study was to evaluate cardiac structural and functional abnormalities utilizing both electrocardiography and echocardiography in patients with CKD undergoing maintenance hemodialysis.

METHODS

This descriptive cross-sectional observational study was carried out at the Pokhara Academy of Health Sciences, Pokhara of Health Sciences, Pokhara, Nepal, from August 2020 to December 2020. All CKD patients undergoing maintenance hemodialysis, age ≥18 years and giving consent for the study were included. Echocardiography was executed by using GE 6Sand 3SC cardiac sector probes assembled to a GE Vivid S5 ultrasound machine incorporating M mode, Color doppler and spectral doppler approaches. The American Society of Echocardiography and the European Association of Cardiovascular Imaging updated protocols were embraced for the acquisition, quantification and reporting of various echocardiographic findings. Updated American College of Cardiology and American Heart Association task force practice guideline was adopted for defining and quantifying valvular heart conditions. Similarly, a 12 lead ECG was performed using GE Marquette MAC 1600 digital ECG portable machine endorsing recommendations laid for Standardization and Interpretation of Electrocardiogram by respective heart rhythm societies. Left ventricular hypertrophy was illustrated by applying voltage criteria i.e., either sex-specific Cornell voltage criteria or Sokolov-Lyon Criteria. European Association of Cardio-Thoracic Surgery protocol was practiced for characterizing atrial fibrillation. Relevant history and other necessary inputs were recorded in Statistical Package for Social Science (SPSS) version 22 for further analysis. Quantitative data were expressed in terms of frequency, percentage, and mean ± standard deviation. The Chi-square test was applied for quantitative data. A p-value of <0.05 was considered significant.

RESULTS

Out of 115 patients included in the study, 74 (64.3%) were male and most of them had hypertension. The mean age and duration of maintenance hemodialysis were 47years and 36 months respectively. Distinct echocardiographic, as well as elctrocardiographic variables, are listed in Table 1.

Table 2 is the distribution of patients having

explicit ECG findings. The most common ECG abnormalities documented were Left Ventricular Hypertrophy (LVH), Left Ventricular Strain Pattern and poor R wave progression.

Table 3 sketches common echocardiographic findings out of which left ventricular diastolic dysfunction, left ventricular hypertrophy and valvular regurgitation (mitral and tricuspid) were most prevalent. Correspondingly, findings like dilated cardiac chamber dimensions and decreased LV systolic functions were noteworthy.

DISCUSSION

Cardiovascular disease remains the major cause of mortality and morbidity in patients with advanced CKD.[13] This study depicted that hypertension was the major risk factor and this was in line with many other studies reporting hypertension to be the leading cause of the end-stage renal disease (ESRD).[14-16] Hypertension is an important determinant of cardiac function in CKD patients since patients with hypertensive ESRD were found to have a higher prevalence of diastolic as well as systolic dysfunction.[16] Electrocardiographic abnormalities are common in CKD patients and the majority of CKD patients are found to have one or more ECG abnormalities.[17] Narrow-based tall T waves suggesting hyperkalemia, prolonged QTc (>450 ms) suggesting hypocalcemia and high QRS voltages in chest leads ($S_{V1} + R_{V5}$ or R_{V6} >35 mm) with LV 'strain' (ST segment depression and T wave inversion in left-sided leads) suggesting left ventricular hypertrophy is considered to be comprising the ECG triad of CKD.[18] Left ventricular hypertrophy and left ventricular strain were bulk ECG abnormalities in our study, followed by poor R wave progression and T wave inversion. Regular maintenance hemodialysis may have amended dyselctrolytemia and this may explain the absence of ECG abnormalities of dyselectrolytemia of ECG triad of CKD in our study.

Atrial fibrillation (AF) is found to be more in CKD patients undergoing maintenance hemodialysis compared to the general population which is in wide range tuning between 1.0 to 27%.[19-21] This occurrence depends on age, various stages of CKD, availability of treatment (i.e., hemodialysis) and the duration of hemodialysis. Our study showed the prevalence of AF to be 2.6 % which was in partial conjunction with little available literature. However, the limitation of this study is the inefficiency to buckle up paroxysmal AF events which are also known to exist in a patient undergoing hemodialysis. Atrial fibrillation is the repercussion of hemodynamic stress resultant from rapid fluid and electrolytes shift during hemodialysis and structural alteration (left atrial dilatation and mitral annular calcification) in CKD patients.[22] Further studies might be necessary to find the incidence, risk factors and prognosis associated with atrial fibrillation among patients with CKD patients as ECG is a simple and cheap test to screen for cardiovascular disease.

Echocardiography is the gold standard diagnostic modality for the identification of cardiac structural and functional. abnormalities that results from CKD.[15] The predominant finding in ESRD is Left Ventricular Hypertrophy (LVH) progressing towards asymmetric septum hypertrophy.[23] Concentric LVH was found in 76.5 % and Eccentric LVH was found in 10.4 % of patients in our study. This study showed a higher prevalence of LVH in patients with CKD, which is consistent with other studies.[10,11,15,16,23-26]

Table 1: Baseline Parameters

Parameters	Mean ± Standard Deviation	Female	Male	p-value
Age (Years)	47.25 ± 15.20	42.54 ± 15.00	49.86 ± 14.77	0.26
Sex		41 (35.7%)	74 (64.3%)	
Duration of CKD (month)	36.42 ± 28.83	30.29 ± 21.82	39.81 ± 31.68	0.43
Risk Factors:				
Diabetes Mellitus	43 (37.4%)	10 (8.7%)	33 (28.7%)	0.03
Hypertension	106 (92.2%)	37 (32.2%)	69 (60.0%)	0.05
Glomerulonephritis	54 (47%)	25 (21.8%)	29 (25.2%)	0.02
Smoking	55 (47.8%)	8 (6.9%)	47 (40.9%)	0.00
Anaemia	65 (56.5%)	18 (15.6%)	47 (40.9%)	0.04
Heart Rate (bpm) in ECG	83.86 ± 13.03	82.85 ± 10.41	84.42 ± 14.31	0.65
Aorta (cm)	2.77 ± 0.38	2.58 ± 0.38	2.86 ± 0.35	0.22
Left Atrium (cm)	3.94 ± 0.53	3.84 ± 0.61	4.00 ± 0.47	0.40
Right Ventricle (cm)	3.49 ± 0.47	3.44 ± 0.39	3.51 ± 0.51	0.87
Main Pulmonary Artery (cm)	1.74 ± 0.37	1.72 ± 0.40	1.75 ± 0.35	0.08
LVIDd (cm)	5.0 ± 0.68	4.82 ± 0.67	5.0 9 ± 0.68	0.91
LVID s (cm)	3.44 ± 0.71	3.30 ± 0.67	3.51 ± 0.73	0.39
IVS (cm)	1.27 ± 0.16	1.21 ± 0.13	1.30 ± 0.17	0.03
LVEF(%)	59.58 ± 8.90	60.78 ± 8.20	58.92 ± 9.26	0.05
LVFS (%)	29.97 ± 4.66	30.59 ± 4.28	29.62 ± 4.85	0.43
PASP (mm of Hg)	36.30 ± 15.86	39.95 ± 16.94	34.28 ± 4.97	0.52

CKD: Chronic Kidney Disease, DM-II: Diabetes Mellitus type 2, GN: Glomerulonephritis, HTN: Hypertension, IVS: Interventricular Septum, LA: Left Atrium, LVEF: Left Ventricular Ejection Fraction, LVIDd: Left Ventricle Internal Dimension during diastole, LVIDs: Left Ventricle Internal Dimension during systole, LVFS: Left Ventricular Fractional Shortening, MPA: Main Pulmonary Artery, PASP: Pulmonary Artery Systolic Pressure, RV: Right Ventricle

Table 2: Common electrocardiographic findings

ECG Parameters	Number of patients	Percentage
Axis		
Left	10	8.7%
Right	3	2.6%
Normal	102	88.7%
Left Ventricular Hypertrophy (LVH)	37	32.2%
Left Ventricular Strain	22	19.1%
Poor R wave Progression	12	10.4%
T Wave Inversion	03	2.6%
Left Bundle Branch Block (LBBB)	07	6.1%
Right Bundle Branch Block (RBBB)	03	2.6%
Atrial Fibrillation	03	2.6%

Table 3: Common Echocardiographic Findings

Echocardiographic Findings	Number of Patients	Percentage
Left Ventricular Diastolic Dysfunction (LVDD)		
Grade I	86	74.8%
Grade II	22	19.1%
Grade III	02	1.7%
Left Ventricular Hypertrophy (LVH)		
Concentric	88	76.5%
Eccentric	12	10.4%
Mitral Regurgitation		
Mild	56	48.7%
Moderate	35	30.4%
Severe	05	4.3%
Aortic Regurgitation		
Mild	51	44.3%
Moderate	0	0%
Severe	0	0%
Tricuspid Regurgitation		
Mild	36	31.3%
Moderate	27	23.5%
Severe	04	3.5%
Pulmonary Regurgitation		
Mild	55	47.8%
Moderate	02	1.7%
Severe	0	0%
Aortic Stenosis (mild)	01	0.9%
Pericardial Effusion		
Mild	07	6.1%
Moderate	03	2.6%
Severe	01	0.9%
Dilated Left Atrium	63	54.8%
Dilated Left Ventricle	23	20%
Dilated Right Atrim& Right Ventricle	13	11.3%
LV Systolic Dysfunction (LVSD)		
Mild	15	13.0%
Moderate	05	4.4%
Severe	03	2.6%

AR: Aortic Regurgitation, AS: Aortic Stenosis, LA: Left Atrium, LV: Left Ventricle, LVDD: Left Ventricular Diastolic Dysfunction, LVH: Left Ventricular Hypertrophy, LVSD: Left Ventricular Systolic Dysfunction, MR: Mitral Regurgitation, PEff: Pericardial EffusionPR: Pulmonary Regurgitation, RA: Right Atrium, RV: Right Ventricle, TR: Tricuspid Regurgitation

Left ventricular diastolic dysfunction (LVDD) is also very frequent among CKD patients and is associated with a risk of heart failure and mortality.[10,24,26] Left ventricular diastolic dysfunction was present in the majority (95.6%) of patients in our study and most of them were mild. Previous studies had shown the varying proportion of LVDD; 47% in the study by Jameel et al.,48.75% in a study by BK et al.,and 61.4% by Laddha et al.[11,15,16] Similarly, 20 % of our patients showed Left Ventricular Systolic Dysfunction (LVSD), similar to 24.3% by Laddha et al. and 27.5% by BK et al. [11,16] Plausible mechanisms suggested for LV dysfunction (both diastolic and systolic) in such patients is the detrimental role of chronic volume and pressure overload, microvascular abnormality and altered neurohormonal adaptation.[16] Action targeted at these pathophysiological processes can overturn or impede this regression of LV function.

Left atrial dilatation was present in a significant proportion (54.8%) of our patients, similar to other studies.[23,24] Protracted volume and pressure overload have been incriminated for this structural change in the LA dimension. [23,24]

Valvular Heart Disease (VHD) is highly prevalent in patients undergoing hemodialysis. Aortic and mitral valves are most frequently affected, leading to the aortic valve and/ or mitral annular calcification and causing either valve stenosis or regurgitation.[27] Mitral regurgitation was the commonest valvular lesion in our study, followed by aortic regurgitation. Altered hemodynamic following volume and pressure overburden results in valvular heart disease in such patients.[27]

Pericardial effusion was 9.6% in our study and the prevalence is similar to other studies as 13.75% prevalence in a study by BK et al., 14.3% prevalence in a study by Laddha et al. and 14% in another study by Bhattacharya et al.[11,14,16] Some studies, however, have reported even lower prevalence of pericardial effusion in CKD.[23] Hemodialysis converses pericardial effusion and its absence connotes the adequacy of hemodialysis.[28]

CONCLUSION

Structural and functional cardiac abnormalities occur in a significant proportion of CKD patients undergoing maintenance hemodialysis, with hypertension identified as a major determinant and the most common structural and functional cardiac defects being LVH and Left ventricular diastolic dysfunction respectively. Assessment by electrocardiography and echocardiography remains a rapid, accessible and cost-effective strategy for CVD risk reduction.

CONFLICT OF INTEREST

None

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None

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