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CORRELATION OF LEFT VENTRICULAR HYPERTROPHY AND DYSFUNCTION ACROSS STAGES, AGE GROUPS, AND TREATMENT MODALITIES IN CHRONIC KIDNEY DISEASE

Medicine

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ABSTRACT

Introduction: Chronic Kidney Disease (CKD) is a major global health issue, particularly due to its strong association with cardiovascular complications like Left Ventricular Hypertrophy (LVH) and Left Ventricular Dysfunction (LVD). These conditions are prevalent in advanced CKD stages and significantly increase the risk of morbidity and mortality. **Aim & Objective:** The study aims to assess the correlation of Left Ventricular Hypertrophy and Dysfunction Across Stages, Age Groups, and Treatment Modalities in Chronic Kidney Disease. **Methodology:** This observational cross-sectional study was conducted at Heritage Institute of Medical Sciences, Varanasi, involving 110 CKD patients aged 18-59 years. Data collection included medical histories, clinical examinations, laboratory tests, and echocardiography. Statistical analysis was performed using SPSS-25. **Results:** The study found that 60.9% of participants were in CKD Stage 5, with worsening serum creatinine, eGFR, and haemoglobin levels as CKD progressed. LVH and systolic dysfunction were significantly more common in patients with CKD for over one year. **Conclusion:** The findings underscore the progressive nature of CKD and its substantial impact on cardiovascular health, highlighting the importance of early intervention and management strategies.

KEYWORDS

Chronic Kidney Disease; Left Ventricular Hypertrophy; Systolic Dysfunction; Cardiovascular Health.

INTRODUCTION

Chronic Kidney Disease (CKD) represents a significant global health burden, not only due to its direct impact on renal function but also because of its profound implications for cardiovascular health.[1] The kidneys, essential organs responsible for filtering waste and maintaining homeostasis, become increasingly compromised as CKD progresses, leading to a host of systemic complications.[2] Among these, Left Ventricular Hypertrophy (LVH) and Left Ventricular Dysfunction (LVD) stand out as particularly concerning, given their strong association with heightened cardiovascular morbidity and mortality.[3,4] Understanding the correlation between CKD stages and these cardiac abnormalities is vital for improving patient outcomes.

Historically, the relationship between CKD and cardiovascular disease has been well-documented, with the earliest records dating back to ancient civilizations.[5,6] Yet, despite advances in medical knowledge and technology, the burden of CKD-related cardiovascular complications continues to rise. In particular, LVH, a structural heart abnormality, is highly prevalent among CKD patients, especially those with End-Stage Renal Disease (ESRD), affecting up to 70% of this population.[7,8] Similarly, Left Ventricular Diastolic Dysfunction (LVDD), which impairs the heart's ability to relax and fill properly, is observed in a significant majority of CKD patients and is closely linked to an increased risk of heart failure and mortality.[9]

The pathogenesis of LVH and LVDD in CKD patients is multifaceted, involving complex mechanisms such as pressure overload, volume overload, and myocardial fibrosis.[10] These cardiac abnormalities often precede clinical symptoms, making early detection and intervention crucial. Echocardiography, a non-invasive and accurate imaging modality, plays a pivotal role in assessing the prevalence and severity of these conditions in CKD patients.[11]

This study aims to correlate Left Ventricular Hypertrophy and Dysfunction Across Stages, Age Groups, and Treatment Modalities in Chronic Kidney Disease. The findings are expected to enhance our understanding of the relationship between CKD and cardiovascular disease, thereby informing more effective early detection and management strategies. Ultimately, this research holds the potential to improve cardiovascular outcomes and reduce mortality rates among CKD patients, addressing a critical need in this high-risk population.

MATERIALS & METHODS

This observational cross-sectional study was conducted at the Department of General Medicine and Nephrology, Heritage Institute of Medical Sciences, Varanasi, Uttar Pradesh, over 18 months, from November 2022 to May 2024. The study involved 110 patients, aged 18 to 59 years, diagnosed with Chronic Kidney Disease (CKD) according to the KDIGO classification. Participants were recruited from outpatient and inpatient departments and through referrals from other departments.

Eligible patients included those diagnosed with CKD who provided informed consent. Both male and female patients were included, whether they were undergoing maintenance haemodialysis or not. Exclusion criteria encompassed individuals with pre-existing cardiovascular conditions such as Rheumatic Heart Disease, Cardiomyopathies, Valvular Heart Disease, Ischemic Heart Disease, or congenital heart disease. Patients with respiratory diseases diagnosed before CKD, pregnant women, those with active malignancy, and individuals with acute on chronic kidney disease were also excluded.

Data collection involved detailed medical histories, including the duration of CKD and haemodialysis status. Vital signs such as blood pressure, pulse rate, temperature, and oxygen saturation were recorded. Blood samples were analyzed for complete haemogram, kidney function tests, blood glucose levels, and HbA1c. Urinary Albumin Creatinine Ratio was measured, and ultrasound imaging of the kidneys and bladder was performed using a Philips Affinity 30 ultrasound machine.

Echocardiography was conducted on all stable patients to evaluate Left Ventricular Hypertrophy (LVH) and Dysfunction, using standard views recorded by an experienced cardiologist blinded to the clinical details. Data were analyzed using SPSS-25, with descriptive statistics and chi-square tests applied to compare categorical variables, considering a p-value of less than 0.05 as statistically significant. The study was approved by the Institutional Ethical Committee, and informed consent was obtained from all participants or their legally authorized representatives.

RESULTS

Table 1 Frequency and Percentage Distribution of Population Characteristics

DEMOGRAPHIC DETAILS		N	(%)
GENDER	Male	82	74.5%
	Female	28	25.5%
AGE GROUP (YEARS)	18-29	12	10.9%
	30-39	20	18.2%
	40-49	28	25.5%
	50-59	50	45.5%

TYPE 2 DIABETES MELLITUS	No	49	44.5%
	Yes	61	55.5%
HYPERTENSION	No	16	14.5%
	Yes	94	85.5%

The table highlights that a significant portion of the study population consists of males (74.5%) and individuals aged 50-59 years (45.5%). Additionally, the majority of participants had hypertension (85.5%) and Type 2 Diabetes Mellitus (55.5%).

Table 2 Combined Summary of CKD Stages, Albumin Creatinine Ratio, and Haemodialysis Status in Study Population

Parameters	N	Percentage (%)
CKD Stage 1	0	0.0%
CKD Stage 2	0	0.0%
CKD Stage 3A	4	3.6%
CKD Stage 3B	14	12.7%
CKD Stage 4	25	22.7%
CKD Stage 5	67	60.9%
A1 (<30 mg/g)	12	10.9%
A2 (30-300 mg/g)	34	30.9%
A3 (>300 mg/g)	64	58.2%
Not on MHD	22	20.0%
On MHD	88	80.0%
Duration of CKD <1 Year	30	27.3%
Duration of CKD >1 Year	80	72.7%

This table summarizes the distribution of CKD stages, urinary albumin creatinine ratios, and haemodialysis status among the 110 study participants. The data reveals that the majority of participants are in advanced CKD stages (Stage 4 and Stage 5) and a significant proportion are undergoing maintenance haemodialysis.

Table 3 Hemodynamic and Biochemical Parameters Based on CKD Stage

CKD Stage		BMI (kg/m²)	SBP (mmHg)	DBP (mm Hg)	Pulse (/min)	EF (%)	S. Creatinine (mg/dl)	eGFR (ml/min/1.73m²)	Haemoglobin (g/dl)
Stage 3A	Mean	25.00	142.00	81.00	86.00	58.75	1.43	53.75	11.18
	SD	0.82	10.95	2.58	6.73	2.50	0.13	2.50	0.46
Stage 3B	Mean	23.86	147.86	81.29	91.43	53.14	2.04	38.71	10.38
	SD	1.29	10.54	4.94	8.02	5.76	0.15	4.89	0.86
Stage 4	Mean	23.08	152.32	85.04	93.68	51.96	3.65	18.76	8.85
	SD	1.19	12.08	5.26	8.32	7.51	0.51	3.22	0.62
Stage 5	Mean	21.96	155.82	86.87		50.10	9.11	6.51	7.81
	SD	1.65	8.19	5.00		7.02	1.73	1.63	0.89

This table provides a comprehensive summary of hemodynamic and biochemical parameters across CKD stages, highlighting trends such as increasing serum creatinine and decreasing eGFR and haemoglobin levels as CKD progresses. The data also shows how blood pressure and pulse rate fluctuate across the different stages of CKD.

Table 4 Representation of LVH, LV Geometry, LV Systolic Dysfunction, EF, and LV Diastolic Dysfunction Based on CKD Duration

Parameter	<1 Year (%)	>1 Year (%)	P-value
LVH	66.7	82.5	0.073
No LVH	33.3	17.5	0.073
Normal Geometry	30.0	11.3	0.042
Concentric Remodeling	3.3	6.3	0.042
Concentric LVH	43.3	36.3	0.042
Eccentric LVH	23.3	46.3	0.042
No LV Systolic Dysfunction	93.3	67.5	0.006
LV Systolic Dysfunction	6.7	32.5	0.006
Preserved EF	93.3	67.5	0.018
Moderately Reduced EF	6.7	21.3	0.018
Reduced EF	0.0	11.3	0.018
No LVDD	46.7	13.8	0.001
Grade 1 LVDD	26.7	48.8	0.001
Grade 2 LVDD	23.3	13.8	0.001
Grade 3 LVDD	3.3	16.3	0.001
Grade 4 LVDD	0.0	7.5	0.001

This table highlights the worsening of cardiac function and geometry as CKD duration extends beyond one year, with significant increases in LV systolic dysfunction, reduced ejection fraction, and advanced diastolic dysfunction.

DISCUSSION

The study found that the majority of the population consisted of males (74.5%) and individuals aged 50-59 years (45.5%). Additionally, 55.5% of participants had Type 2 Diabetes Mellitus, and a significant 85.5% were diagnosed with hypertension. These findings highlight a higher prevalence of older males and the common presence of comorbid conditions such as hypertension and diabetes in this study population. **Paoletti et al.**[11] reported a similar demographic profile with 68.4% males and a predominant age group of 50-59 years (44.3%). Their study also found a comparable prevalence of hypertension (83.6%). On the other hand, Singh et al. observed 72.5% males and 48.5% aged 50-59 years, with a slightly lower hypertension prevalence (79.5%) and a higher prevalence of Type 2 Diabetes Mellitus (61.5%). These comparisons suggest consistency across studies, with slight variations likely due to differences in study populations or settings.

The study found that the majority of participants were in the advanced stages of Chronic Kidney Disease (CKD), with 60.9% (67 out of 110) in CKD Stage 5 and 22.7% (25 participants) in CKD Stage 4. Only a small percentage of participants were in CKD Stage 3B (12.7%) and CKD Stage 3A (3.6%), with no participants in CKD Stages 1 or 2. Regarding the urinary albumin creatinine ratio, 58.2% (64 participants) had an A3 level (>300 mg/g), indicating significant proteinuria, while 30.9% (34 participants) had an A2 level (30-300 mg/g), and 10.9% (12 participants) had an A1 level (<30 mg/g). Additionally, a significant proportion of the population, 80.0% (88 participants), was undergoing maintenance haemodialysis (MHD), with only 20.0% (22 participants) not on MHD. The study also revealed that 72.7% (80 participants) had been living with CKD for more than one year, while 27.3% (30 participants) had CKD for less than one year. **Paoletti et al.**[11], their study also reported a majority in CKD Stage 5 (63.5%) and a similar prevalence of proteinuria, with 54.1% at the A3 level. They found that 78.4% were on MHD, closely matching the 80.0% in the current study. **Singh et al.**[13], focusing on non-dialysis CKD patients, found slightly lower percentages in Stage 5 (55.0%) and a lower proportion on haemodialysis (72.0%), though they also reported 56.0% with an A3 albumin creatinine ratio, aligning with our study's findings.

The study found that as Chronic Kidney Disease (CKD) progressed from Stage 3A to Stage 5, significant changes in hemodynamic and biochemical parameters were observed. The Body Mass Index (BMI) decreased from a mean of 25.00 kg/m² in Stage 3A to 21.96 kg/m² in Stage 5. Systolic Blood Pressure (SBP) increased from 142.00 mmHg in Stage 3A to 155.82 mmHg in Stage 5, while Diastolic Blood Pressure (DBP) rose from 81.00 mmHg to 86.87 mmHg. Pulse rate showed slight fluctuations, peaking at 93.68 bpm in Stage 4. Ejection Fraction (EF) declined from 58.75% in Stage 3A to 50.10% in Stage 5, indicating worsening cardiac function. Serum creatinine levels significantly increased from 1.43 mg/dl in Stage 3A to 9.11 mg/dl in Stage 5, while eGFR decreased sharply from 53.75 ml/min/1.73m² to 6.51 ml/min/1.73m². Haemoglobin levels also declined, from 11.18 g/dl in Stage 3A to 7.81 g/dl in Stage 5, reflecting the worsening anemia associated with CKD progression. **Naz et al.**[12], found that serum creatinine levels increased to 9.45 mg/dl in End-Stage Renal Disease (ESRD) patients, similar to the 9.11 mg/dl observed in Stage 5 in this study. They also reported a comparable decline in eGFR in advanced CKD stages. **Debnath et al.**[14] similarly observed a decline in EF from 57.80% in Stage 3 to 48.60% in Stage 5, closely matching the decline from 58.75% to 50.10% observed in this study. Additionally, their findings of increased SBP and DBP in advanced CKD stages align with the trends observed in the current study, reinforcing the progressive deterioration of cardiovascular and kidney function in CKD.

The study found that cardiac function and geometry significantly worsened as the duration of Chronic Kidney Disease (CKD) extended beyond one year. Left ventricular hypertrophy (LVH) was more prevalent in patients with CKD for over one year (82.5%) compared to those with less than one year (66.7%), with a p-value of 0.073. Normal left ventricular geometry decreased from 30.0% in patients with less than one year of CKD to 11.3% in those with more than one year (p-value = 0.042). Additionally, eccentric LVH increased from 23.3% to 46.3% as CKD duration increased. Left ventricular systolic

dysfunction (LVSD) was more common in patients with CKD for more than one year (32.5% vs. 6.7%, p-value = 0.006), with a corresponding decline in ejection fraction. The incidence of reduced ejection fraction (EF < 40%) was 11.3% in those with CKD for more than one year, compared to 0% in those with CKD for less than one year (p-value = 0.018). Left ventricular diastolic dysfunction (LVDD) also worsened with CKD duration, with higher grades of LVDD significantly more common in patients with CKD for over a year (p-value = 0.001). **Paoletti et al.**[11], who examined the progression of left ventricular hypertrophy and dysfunction in CKD patients. Their study found that the prevalence of LVH increased with the duration of CKD, with 79.5% of patients with CKD for more than a year exhibiting LVH, compared to 65.3% of those with less than a year, closely matching the 82.5% and 66.7% observed in the current study. They also reported a decline in normal LV geometry as CKD duration increased, with only 12.1% of patients maintaining normal geometry after one year, similar to the 11.3% found in the study. Additionally, **Paoletti et al.** found that the prevalence of LVSD increased significantly over time, with 29.8% of patients experiencing LVSD after more than a year of CKD, which is consistent with the 32.5% observed in this study.

CONCLUSION

This study reveals that the majority of the population consists of older males, predominantly in the 50-59 age group, with a high prevalence of hypertension and Type 2 Diabetes Mellitus. Most participants are in advanced CKD stages (Stages 4 and 5), with a significant portion undergoing maintenance haemodialysis. As CKD progresses, there is a clear trend of worsening hemodynamic and biochemical parameters, including increasing serum creatinine levels, decreasing eGFR and haemoglobin levels, and fluctuations in blood pressure and pulse rate. Additionally, the duration of CKD significantly impacts cardiac function, with a marked increase in left ventricular hypertrophy, systolic dysfunction, reduced ejection fraction, and advanced diastolic dysfunction in patients with CKD for more than one year. These findings underscore the progressive nature of CKD and its substantial impact on cardiovascular health.

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