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CORRELATION OF LEFT ATRIAL VOLUME INDEX AND E-GFR IN PATIENTS OF CHRONIC KIDNEY DISEASE AT A TERTIARY CARE CENTRE

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ABSTRACT

Background: Chronic kidney disease patients have an increased risk of cardiovascular morbidity and mortality. LAVI (Left Atrial Volume Index) serves as an indicator of left ventricular diastolic dysfunction and is part of the cardiac remodeling process seen in various cardiovascular diseases. Studies have shown that left atrial dilatation correlates with the progression of left ventricular dysfunction, making it crucial to monitor cardiovascular health in CKD patients, especially in those awaiting renal transplantation.

Methods: A total of 100 CKD patients (outpatients and inpatients) from hospitals affiliated with BMCRI were included. The study was conducted through history, physical examination, renal function tests, and 2D echocardiography. The patients were evaluated based on their e-GFR (estimated Glomerular Filtration Rate), clinical stage of CKD, and echocardiographic parameters, including LAVI, LVSD (Left Ventricular Systolic Dysfunction), and hypertrophy.

Results: The mean serum urea level was 88.52 ± 48.44 mg/dL. The majority of patients (61%) were in Stage 5 CKD, with 60% undergoing hemodialysis. Echocardiographic findings showed that 99% of patients had LVSD, and 53% exhibited left ventricular hypertrophy. The LAVI was significantly higher in patients on hemodialysis (p=0.01) and increased with the worsening CKD stage (p=0.003). There was a strong correlation between LAVI and LVSD (p=0.001), and hypertension further worsened LVSD (p=0.038).

Conclusion: Patients with CKD stages 3-5 exhibit an increased LAVI, indicating left atrial enlargement and dysfunction. Early screening using echocardiography in these patients can help assess cardiovascular risk, allowing for timely interventions to mitigate cardiovascular disease and improve patient outcomes.

Keywords: Left Atrial Volume Index, Chronic Kidney Disease, End-Stage Renal Disease, Left Ventricular Systolic Dysfunction, Echocardiography.

INTRODUCTION

Chronic kidney disease is characterized by persistent renal dysfunction for three or more months, evidenced by altered markers of renal function or renal biopsy findings, irrespective of a decrease in e-GFR (estimated Glomerular Filtration Rate).[1] Alternatively, CKD can be defined by a reduction in e-GFR (< 60 mL/min/1.73 m²) for three or more months, regardless of the presence of other renal dysfunctions.[1] Reduced e-GFR and albuminuria are independent risk factors for all-cause mortality, as well as CV (Cardiovascular) morbidity and mortality.[2] Even mild renal impairment indicated by asymptomatic albuminuria is associated with an elevated risk of CVD (Cardiovascular Disease), as it may signal endothelial dysfunction and compromised microvascular integrity. In CKD and ESRD (End-Stage Renal Disease) patients, CVD is the leading cause of morbidity and mortality, and they are more likely to die from CVD than to progress to ESRD.[3] To mitigate this risk, early detection of CKD, especially in asymptomatic or mildly impaired patients, is crucial. Screening with cost-effective, non-invasive modalities such as ECG (Electrocardiograms) and 2-dimensional echocardiography (2D-ECHO) is recommended. The National Kidney Foundation advises baseline ECG and echocardiography at the initiation of dialysis and yearly thereafter to monitor cardiovascular health in dialysis patients.[4] Echocardiographic abnormalities such as LVH (Left Ventricular Hypertrophy), LVDD and LVSD (Left Ventricular Diastolic Dysfunction and Left Ventricular Systolic Dysfunction), PAH (Pulmonary Arterial Hypertension), pericardial effusion, and LAE (Left Atrial Enlargement) are commonly observed in CKD patients. Research has shown that elevated LAV (Left Atrial Volume) is strongly associated with higher cardiovascular risk, providing valuable information about myocardial involvement in CKD.[5,6] The LAVI (Left Atrial Volume Index), derived by adjusting LAV for BSA (Body Surface Area), serves as a reliable marker of myocardial strain and cardiac remodeling in CKD patients.[7,8,9]

AIMS AND OBJECTIVES

The study aims to evaluate the relationship between e-GFR and LAVI in patients with CKD. Specifically, the objectives are to measure e-GFR and LAVI using 2-dimensional echocardiography in CKD patients and to explore the correlation between these two parameters, thereby assessing how changes in renal function may influence left atrial size and cardiac remodeling in this population.

MATERIALS AND METHODS

Study Design

The study was an observational cross-sectional study conducted on patients with CKD attending the outpatient and inpatient departments of medicine in hospitals affiliated with BMCRI. The data for the study were collected over a period from August 2022 to November 2023, focusing on CKD patients to assess the correlation between e-GFR and LAVI.

Inclusion and Exclusion Criteria

The study included patients aged above 18 years who were diagnosed with CKD according to the National Kidney Foundation guidelines and were willing to provide informed consent. Patients were excluded if they had known ischemic or coronary heart disease, valvular heart disease, cardiomyopathy, atrial fibrillation, or congestive heart failure, as these conditions could independently affect cardiac structure and function, thereby confounding the assessment of the correlation between e-GFR and LAVI.

Sample Size Calculation

Based on a study by Syed Rizwan Bokhari et al.[10] the e-GFR value among CKD patients was 106.96 +/- 21.29.

According to the formula $N= (Z)^2_{\alpha/2} \cdot \sigma^2/d^2$

$Z_{\alpha/2}$=1.96 at 95% CI σ= 21.29
d=precision=5% on mean=5.348
n= $(1.96)^2$ x $(21.29)^2$/ $(5.348)^2$
n= 85
The sample size was approx. 85
By adding 10% to the attrition = 85 + 8.5 = 93.5
Therefore the sample size was approx. 94 for statistically significant results.
Total sample size taken for the study was 100

Data Collection Procedure

After obtaining approval and clearance from the Institutional Ethics Committee, patients meeting the inclusion criteria were enrolled in the study following informed consent. A detailed case record form along with a follow-up chart was maintained for each participant. Relevant investigations were carried out, including serum creatinine levels and 2D echocardiography. The BSA of each participant was calculated using the Mosteller formula, and the e-GFR was determined using the CKD-EPI equation. Based on the biochemical parameters, each patient was staged for CKD accordingly. Subsequently, all patients underwent 2D echocardiography, and the LAVI was measured. Finally, a correlation between e-GFR and LAVI was analyzed to study their relationship in CKD patients.

Statistical Analysis

Statistical analysis was performed using SPSS version 21 (IBM SPSS Statistics, IBM Corporation, NY, USA). The data were first entered into a spreadsheet and checked for errors. Descriptive statistics were calculated for both explanatory and outcome variables, including means and standard deviations for quantitative variables, as well as frequencies and proportions for qualitative variables. Inferential statistics included the use of chi-square tests to assess associations between qualitative variables. A significance level of 5% was considered for all statistical tests.

RESULTS

Variable	Categories	Frequency	Percentage
Age groups (in years)	20–35	22	22%
	36–50	21	21%
	51–65	43	43%
	66–80	14	14%
Gender	Male	66	66%
	Female	34	34%

Table 1: Demographic Profile of the Study Population

Table 1 shows that the mean age of the study subjects was 50.7 ± 15.4 years, with most participants (43%) between 51 and 65 years. Two-thirds were males (66%) and one-third were females (34%).

Variable	Categories	Frequency	Percentage
Chief Complaints	Breathlessness	33	33%
	Lower limb swelling	30	30%
	Reduced urine output	12	12%
	Others (fever, puffiness, sensorium changes, etc.)	25	25%
Hypertension	Present	75	75%
	Absent	25	25%
Diabetes Mellitus	Present	59	59%
	Absent	41	41%

Table 2: Clinical Characteristics and Comorbidities

Table 2 observes that the most common clinical complaints were breathlessness (33%) and swelling of lower limbs (30%). Hypertension (75%) and diabetes (59%) were the major comorbidities.

CKD Stage	Frequency	Percentage
Stage 3A	3	3%
Stage 3B	14	14%
Stage 4	22	22%
Stage 5	61	61%
Hemodialysis	Yes	60
	No	40

Table 3: Distribution by Stage of CKD and Hemodialysis Status

Table 3 shows that the majority of patients (61%) were in stage 5 CKD, and 60% were on regular hemodialysis.

Parameter	Mean ± SD	Range
Serum Urea (mg/dL)	88.5 ± 48.4	20–270
Serum Creatinine (mg/dL)	5.6 ± 3.2	1.6–13.3
Creatinine Clearance (mL/min)	16.2 ± 12.0	4–47
Left Atrial Volume (mL)	31.6 ± 6.6	18–46
Body Surface Area (m^2)	1.04 ± 0.17	0.7–1.4
PASP (mmHg)	41.3 ± 16.3	22–85

Table 4: Mean Laboratory and Echocardiographic Parameters

Table 4 illustrates the biochemical and cardiac profiles, with raised urea/creatinine and reduced clearance indicating severe renal impairment. PASP was moderately elevated on average.

Parameter	Categories	Frequency	Percentage
LAV Index	Grade 1	40	40%
	Grade 2	24	24%
	Grade 3	4	4%
	Normal	32	32%
LVH	Mild	30	30%
	Moderate	17	17%
	Severe	6	6%
	Normal	47	47%
LV Systolic Dysfunction	Mild	89	89%
	Moderate	10	10%
	None	1	1%
HHD	Present	27	27%
	Absent	73	73%

Table 5: Echocardiographic Abnormalities

Table 5 observes that mild LV systolic dysfunction was the most common finding (89%), followed by mild LVH (30%) and Grade 1 LAV index (40%). HHD was seen in 27% of patients.

Parameter	On HD (n=60)	Not on HD (n=40)	P-Value
LV Systolic Dysfunction	Mild 90% vs 87.5%	Moderate 8.3% vs 12.5%	0.57
LVH	Mild 33.3% vs 25%	Moderate 15% vs 20%	0.76
LAV Index	Grade 1: 30% vs 55%	Grade 2: 28.3% vs 17.5%	**0.01*

Table 6: Association of Echocardiographic Findings with Hemodialysis

Table 6 shows that the LAV index had a significant association with hemodialysis requirements (p=0.01), while LVH and LV systolic dysfunction were not significantly related.

Association	Significant Findings	P-Value
CKD Stage	LVSD (p=0.001), LAV index (p=0.003) significantly worsened with advanced stages	<0.05
Hypertension	LVSD significantly associated (p=0.03)	<0.05
LVSD vs. LAV Index	Higher LAV index correlated with worsening LVSD	0.001

Table 7: Association of Echocardiographic Findings with CKD Stage, HTN, and LAV Index

Table 7 demonstrates that worsening CKD stage correlated with increased LV dysfunction and higher LAV index. Hypertension also significantly impacted LVSD. LAV index and LVSD had a strong interrelation.

DISCUSSION

This cross-sectional hospital based study was conducted to analyze the correlation between LAVI and e-GFR across various stages of CKD. Patients with known ischemic heart disease, valvular or congenital heart disease, cardiomyopathy, atrial fibrillation, and congestive heart failure were excluded to minimize confounding factors affecting cardiac structure and function.

Age Distribution

The mean age of study participants was 50.75 ± 15.42 years, with the majority (43%) falling in the 51–65-year age group. These findings are consistent with prior studies such as Michael Dahan et al. (48.7 ± 13.5 years),[11] Foley et al. (51 ± 17 years),[12] and Ramy Saafan et al. (59.63 ± 8.50 years).[13]

Gender Distribution

In our study, 66% of patients were male and 34% were female, with a male-to-female ratio of approximately 2:1, comparable to findings from Owen et al.[14] and Foley et al.[12]

CKD Staging

Most patients were in stage 5 CKD (61%), followed by stage 4 (22%) and stage 3B (14%). Only 3% were in stage 3A, and none were in stages 1 or 2, reflecting a higher burden of advanced CKD among hospital-attending patients.

Hemodialysis

A total of 60% of the patients were on HD (Hemodialysis), emphasizing the advanced nature of kidney dysfunction in the study cohort.

Renal Function

The mean serum urea was 88.52 ± 48.44 mg/dL and the mean serum creatinine was 5.61 ± 3.23 mg/dL. The mean creatinine clearance (e-GFR) was 16.23 ± 12.01 mL/min/1.73 m², which aligns with the findings of D.S. Chafekar et al.[15] who reported similar values (urea: 77.07 ± 25.39 mg/dL; creatinine: 5.75 ± 1.32 mg/dL).

Comorbidities

Hypertension was observed in 75% of patients (27% had hypertensive heart disease), and 59% had diabetes mellitus, underscoring the high prevalence of cardiovascular risk factors in CKD patients.

Echocardiographic Findings

LVH was present in 53% of patients, with varying severity (mild: 30, moderate: 17, severe: 6). LVSD was seen in 99% of patients, mostly mild (89%), while 10% had moderate dysfunction. The mean PASP (Pulmonary Artery Systolic Pressure) was 41.30 ± 16.31 mmHg.

LAV and LAVI Findings

The mean LAV was 31.60 ± 6.58 ml, and the mean LAVI was 34.11 ± 7.39 ml/m², which is comparable to previous studies: Ramy Saafan et al. (36.20 ± 8.21 ml/m²),[13] Krishna K. Kadappu et al. (38.5 ± 10 ml/m²),[7] Syed Rizwan Bokhari et al. (33.33 ± 11.71 ml/m²)[10] and Mansur A. et al. (42.62 ± 10.24 ml/m²).[16] In our study, 40% of patients had Grade 1 LAVI elevation, 24% had Grade 2, and 4% had Grade 3.

Statistical Correlations

- LAVI was significantly higher in patients on hemodialysis (p = 0.01).
- LAVI increased significantly with worsening CKD stage and had a negative correlation with e-GFR (p = 0.003).
- LV systolic dysfunction worsened with advancing CKD stages (p = 0.001).
- A strong association was observed between worsening LVSD and increased LAVI (p = 0.001).
- The presence of hypertension significantly correlated with worsened LVSD (p = 0.038).

Comparison with Previous Studies

When compared with other studies, our findings are in close agreement in terms of both e-GFR and LAVI values. Studies by Bokhari SR et al.[15] Nguyen HTT et al.[17] Mahmood A et al.[16] Kadappu KK et al.[7] Nguyen T et al.[18] and Kashioulis P et al.[19] reported LAVI values ranging between 32.0 and 38.5 ml/m² and e-GFR values between 23.4 and 48.9 ml/min, which are comparable to our study's LAVI (34.1 ± 7.3 ml/m²) and e-GFR (16.2 ± 12 ml/min/1.73 m²).

Overall, the study confirms that LAVI is a reliable marker of cardiac remodeling and dysfunction in CKD, and it demonstrates a significant inverse correlation with e-GFR, making it a useful non-invasive tool for cardiovascular risk stratification in this population.

CONCLUSION

CKD is a significant contributor to cardiovascular morbidity and mortality, with our study demonstrating a high prevalence of left ventricular hypertrophy (53%) and systolic dysfunction (99%) among CKD patients. The mean LAVI was 34.11 ± 7.39 ml/m², showing a significant increase with advancing CKD stage, initiation of hemodialysis, worsening LV systolic dysfunction, and presence of hypertension. These findings highlight the strong inverse correlation between e-GFR and LAVI, reinforcing the role of cardiac remodeling in CKD progression. Given the high cardiovascular risk in this population, routine screening using non-invasive, cost-effective modalities such as 2D echocardiography is essential, particularly in resource-limited settings like India. Early identification of subclinical cardiac changes can enable timely intervention, reduce cardiovascular complications, and improve outcomes-especially in patients eligible for renal transplantation before irreversible cardio-renal damage sets in.

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