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Original Research Article

Prevalence and Predictors of Arrhythmias in Chronic Kidney Disease Patients on Dialysis: A Hospital-Based Observational Study

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Abstract:

Background: Chronic kidney disease (CKD) patients on dialysis are at high risk of cardiovascular complications, with arrhythmias being a major contributor to morbidity and sudden cardiac death. Data from India on the prevalence and predictors of arrhythmias in this population remain limited.

Methods: This cross-sectional observational study was conducted at a tertiary care center in India and included 100 adult patients with stage 5 CKD on maintenance dialysis. Demographic, clinical, and dialysis-related details were recorded, and arrhythmias were assessed using 12-lead electrocardiography performed pre- and post-dialysis. Selected patients underwent 24-hour Holter monitoring. Patients were grouped by arrhythmia status and compared for risk factors. Logistic regression analysis was used to identify independent predictors.

Results: Arrhythmias were observed in 30% of patients, with atrial fibrillation/flutter being the most frequent, followed by premature ventricular complexes, conduction abnormalities, and supraventricular tachycardia. Patients with arrhythmias were older and had a higher prevalence of diabetes and coronary artery disease. Hypokalemia and longer dialysis vintage were also more frequent in this group. On multivariate analysis, older age, diabetes mellitus, coronary artery disease, and hypokalemia were independent predictors of arrhythmia.

Conclusion: Nearly one-third of CKD patients on maintenance dialysis developed arrhythmias, with atrial fibrillation being most common. Age, diabetes, coronary artery disease, and hypokalemia significantly increased arrhythmic risk. While non-modifiable comorbidities contribute, careful attention to electrolyte balance and dialysis parameters may help reduce risk. Routine ECG surveillance and targeted preventive strategies are recommended to improve outcomes in this high-risk population.

Keywords: Chronic kidney disease, Hemodialysis, Arrhythmia, Atrial fibrillation, Hypokalemia, Cardiovascular complications.

Introduction

Chronic kidney disease (CKD) is a growing global health problem, with cardiovascular disease being the leading cause of morbidity and mortality among affected patients. [1] Among cardiovascular complications, arrhythmias play a major role, often contributing to sudden cardiac death, which accounts for nearly one-fourth of deaths in dialysis populations. [2] Patients on maintenance dialysis are particularly vulnerable due to a combination of structural heart disease, autonomic dysfunction, electrolyte shifts, and dialysis-related hemodynamic changes. [3]

The pathogenesis of arrhythmias in CKD is complex and multifactorial. Left ventricular hypertrophy, myocardial fibrosis, and uremic toxins provide a vulnerable substrate, while rapid changes in potassium, calcium, and acid–base status during dialysis act as acute triggers. [4] Additional factors such as anemia, fluid overload, and ischemic heart disease further increase susceptibility. Consequently, both atrial and ventricular arrhythmias, as well as conduction disturbances, are common in this group. [5] Epidemiological data from Western registries, including the US Renal Data System, suggest that 15–40% of dialysis patients experience arrhythmias, with atrial fibrillation being particularly prevalent. [6]

The risk of sudden cardiac death in this population is estimated to be 10–20 times higher than in the general population. However, most of this evidence comes from developed countries. [7] In India and other low- and middle-income nations, patients tend to be younger, have a high prevalence of diabetes and hypertension, and often present late for renal replacement therapy. [8] Dialysis

practices also differ, making it inappropriate to directly extrapolate Western data. [9] Another important challenge is underdiagnosis. Intermittent 12-lead ECGs may miss transient or paroxysmal arrhythmias, while Holter monitoring, though more sensitive, is rarely feasible in routine clinical care. [10] In such settings, identifying simple clinical and biochemical predictors of arrhythmias—such as dialysis duration, ultrafiltration volume, serum electrolytes, and comorbidities—can provide a cost-effective approach to risk stratification. [11] Early detection of arrhythmias has clear therapeutic implications. Atrial fibrillation increases the risk of stroke, yet anticoagulation decisions in CKD are difficult due to high bleeding risk. Ventricular arrhythmias are life-threatening but preventive interventions, including tailoring dialysate composition and optimizing fluid management, can mitigate risks if high-risk patients are recognized. Thus, characterizing arrhythmia prevalence and its determinants is essential for improving patient outcomes. [12]

Despite the significance of this problem, Indian data remain limited. Most available studies are small, single-center, and heterogeneous in methodology. There is a need for contemporary, hospital-based evidence to understand the true burden and predictors of arrhythmias in Indian dialysis patients.

Material and Methods

This cross-sectional observational study was conducted in the Department of General Medicine at a tertiary care center in India after obtaining Institutional Ethics Committee approval and informed consent. A total of 100 consecutive adult patients (≥18 years) with stage 5 chronic kidney disease on maintenance dialysis for at least one month were enrolled. Patients with permanent pacemakers, implantable cardioverter-defibrillators, known congenital arrhythmic disorders, or acute intercurrent illness requiring intensive care were excluded.

Demographic data, comorbidities (hypertension, diabetes, coronary artery disease, heart failure, cerebrovascular disease), etiology of CKD, dialysis details (duration on dialysis, frequency, ultrafiltration volume, dialyzer membrane, residual urine), and drug history were recorded. Laboratory parameters including hemoglobin, serum electrolytes (sodium, potassium, calcium, and phosphate), bicarbonate, parathyroid hormone, and lipid profile were documented within the same week as arrhythmia assessment. Arrhythmias were evaluated by standard 12-lead electrocardiography (ECG) performed pre- and post-dialysis for hemodialysis patients and during routine visits for peritoneal dialysis patients. A subset of patients underwent 24-hour Holter monitoring where feasible. ECGs were interpreted independently by two physicians and classified into atrial fibrillation/flutter, supraventricular tachycardia, ventricular arrhythmias, premature atrial or ventricular complexes, conduction disturbances, bradyarrhythmias, or prolonged QTc using standard definitions. The primary outcome was the prevalence of arrhythmias, and secondary outcomes included identification of clinical, biochemical, and dialysis-related predictors. Patients were grouped according to arrhythmia status, and comparative analysis was performed.

Data were analyzed using SPSS version 26. Continuous variables were expressed as mean ± SD or median (IQR), and categorical variables as frequencies and percentages. Group comparisons employed t-test or Mann–Whitney U test for continuous variables and chi-square or Fisher's exact test for categorical variables. Logistic regression was used to identify independent predictors, with results expressed as adjusted odds ratios and 95% confidence intervals. A p-value <0.05 was considered statistically significant.

Results

A total of 100 patients with CKD on maintenance dialysis were included in the study. The mean age of the study population was 52.6 ± 12.4 years, with a male-to-female ratio of 1.8:1. The most common etiologies of CKD were diabetic nephropathy (42%), hypertensive nephrosclerosis (28%), and chronic glomerulonephritis (15%). Hypertension was present in 82% of patients, diabetes in 46%, and coronary artery disease in 18%. The median dialysis vintage was 24 months (IQR 12–36), and 92% of patients were on hemodialysis while 8% were on peritoneal dialysis.

Overall, 30 patients (30%) were found to have arrhythmias on ECG and/or Holter monitoring. The most frequent arrhythmia was atrial fibrillation/flutter (12%), followed by premature ventricular complexes (8%), conduction abnormalities such as bundle branch block or AV block (6%), and supraventricular tachycardia (4%). Ventricular tachyarrhythmias were noted in 2 patients. Post-dialysis ECGs detected a higher proportion of new arrhythmias compared to pre-dialysis tracings.

Table 1. Type of Arrhythmia

Types	Number (%)
Atrial fibrillation/flutter	12 (12%)
Premature ventricular complexes	8 (8%)

Conduction blocks (AV/BBB)	6 (6%)
Supraventricular tachycardia	4 (4%)
Ventricular tachyarrhythmias	2 (2%)

Patients with arrhythmias were significantly older (56.8 ± 11.5 vs 50.5 ± 12.6 years, p = 0.02) and more likely to have diabetes (63% vs 37%, p = 0.01) and coronary artery disease (30% vs 12%, p = 0.03) compared to those without arrhythmias. Laboratory parameters showed that hypokalemia (K+ <3.5 mmol/L) was more common in patients with arrhythmias (27% vs 10%, p = 0.04), as was hypocalcemia (23% vs 9%, p = 0.05).

Dialysis-related factors such as longer dialysis vintage (>24 months) and higher ultrafiltration volume (>3 L/session) were also associated with arrhythmia occurrence (p <0.05).

Table 2. Independent predictors of arrhythmia

Predictor	Adjusted OR	95% CI	p-value
Age (per year)	1.05	1.01–1.10	0.02*
Diabetes mellitus	2.3	1.1–5.1	0.04*
Coronary artery disease	2.7	1.1–6.8	0.03*
Hypokalemia	3.1	1.0–9.2	0.04*

***Significant**

On multivariate logistic regression, the independent predictors of arrhythmias in dialysis patients were older age, presence of diabetes mellitus, coexistent coronary artery disease, and hypokalemia.

Discussion

In this hospital-based study of 100 patients with chronic kidney disease on maintenance dialysis, arrhythmias were detected in nearly one-third of the cohort. The most frequent rhythm abnormality was atrial fibrillation, followed by premature ventricular complexes, conduction disturbances, and supraventricular tachycardias. These findings highlight the significant arrhythmic burden among Indian dialysis patients, a population already predisposed to adverse cardiovascular outcomes. In our study of 100 CKD patients on dialysis, arrhythmias were detected in 30%, with atrial fibrillation being the most frequent type.

The mean age was 52.6 years, with diabetic nephropathy and hypertension as leading etiologies. These findings are similar to Panjiyar et al. (2017) [13] from Nepal, who reported hypertension and diabetes as the major causes of ESRD with a slightly older mean age, and to Tsagalis et al. (2011) [14] in Greece, who described an older cohort (65 years) with a higher burden of hypertension and coronary artery disease. Park et al. (2022) [15] also confirmed diabetes and hypertension as key predictors of adverse outcomes, supporting the consistency of metabolic risk factors across populations. The prevalence of arrhythmias in our cohort (30%) is comparable to the 30% reported by Panjiyar et al. (2017) [13] and close to the 23% atrial fibrillation prevalence noted by Tsagalis et al. (2011) [14]. Atrial fibrillation was the dominant arrhythmia in both our study and in these cohorts, while Park et al. (2022) [15] also highlighted atrial premature complexes and supraventricular abnormalities as significant predictors of adverse cardiovascular events. Age was an independent predictor in our study, aligning with Tsagalis et al. (2011) [14], who observed a clear age-dependent rise in atrial fibrillation prevalence, and Park et al. (2022) [15], who identified age as a determinant of major ECG abnormalities. Wang et al. (2021) [16] also demonstrated older age as a risk factor for AF-related complications in Chinese patients, reinforcing its role as a universal predictor.

Similarly, diabetes and coronary artery disease independently predicted arrhythmias in our patients, findings supported by Panjiyar et al. (2017) [13], Tsagalis et al. (2011), and Park et al. (2022) [15], all of whom showed strong associations between these comorbidities and arrhythmia or cardiovascular complications. Electrolyte disturbances, particularly hypokalemia, significantly contributed to arrhythmias in our cohort. While not all studies directly assessed potassium, Panjiyar et al. (2017) [13] reported significant links between calcium–phosphate imbalance and cardiovascular complications, and Park et al. (2022) [15] emphasized metabolic disturbances such as elevated hsCRP as predictors of ECG abnormalities. These findings together support the critical role of biochemical shifts in arrhythmogenesis.

Dialysis-related variables such as longer vintage and higher ultrafiltration volume were associated with arrhythmias in univariate analysis, echoing Tsagalis et al. (2011) [14] and the PACE study (Parekh et al., 2015) [17], which showed dialysis duration and treatment intensity to influence arrhythmic risk. Overall, our results are consistent with both regional and international data, emphasizing age, diabetes, coronary artery disease, and electrolyte imbalance as key predictors of arrhythmias in dialysis patients. Importantly, while some of these risks are non-modifiable, others such

as potassium shifts and dialysis-related factors are correctable, highlighting opportunities for prevention through careful monitoring and individualized dialysis prescriptions.

The study was conducted at a single tertiary care center with a relatively small sample size, which may limit generalizability. Arrhythmia detection relied mainly on ECG with limited Holter monitoring, so transient or paroxysmal events may have been underdiagnosed. Long-term outcomes such as stroke, hospitalization, or mortality were not assessed.

Conclusion

Arrhythmias were prevalent in nearly one-third of CKD patients on maintenance dialysis in our study, with atrial fibrillation being the most common type. Older age, diabetes mellitus, coronary artery disease, and hypokalemia emerged as significant predictors, underscoring the combined impact of non-modifiable and modifiable risk factors.

While comorbidities such as age and cardiovascular disease cannot be altered, careful correction of electrolyte disturbances and optimization of dialysis parameters may reduce arrhythmic risk. Our findings highlight the need for routine cardiac monitoring and targeted preventive strategies to improve cardiovascular outcomes in this vulnerable population.

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