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A Study to Assess the Risk Factors Associated with Sudden Death in Population on Hemodialysis

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Abstract

Background: *Patients with chronic kidney disease (CKD) receiving maintenance hemodialysis (HD) experience disproportionately high mortality, with sudden death remaining a leading cause. Multiple clinical, biochemical, and care-related factors influence outcomes, yet comprehensive risk stratification models and the role of dialysis timing and early nephrology care remain inadequately explored in resource-limited settings.* ***Objectives:*** *This study aimed to (i) identify clinical and biochemical risk factors associated with mortality in HD patients, (ii) evaluate the impact of interdialytic intervals on sudden death, and (iii) assess the influence of early nephrology care on one-year mortality among patients initiating renal replacement therapy (RRT).* ***Methods:*** *A prospective observational study was conducted among adult patients undergoing maintenance hemodialysis. Baseline demographic, clinical, laboratory, electrocardiographic, and echocardiographic parameters were recorded. Multivariable logistic regression analysis was used to identify independent predictors of mortality and to develop a mortality prediction model. The effect of interdialytic intervals on sudden death was analyzed using time-based mortality assessment. Survival outcomes were evaluated using Kaplan–Meier analysis, and the impact of early versus late nephrology referral was examined.* ***Results:*** *Several factors, including advanced age, cardiovascular comorbidities, electrolyte disturbances, prolonged interdialytic intervals, and inadequate pre-dialysis care, were significantly associated with increased mortality. Sudden death was more frequent during longer interdialytic intervals, particularly following the long weekend gap. Early nephrology care prior to dialysis initiation was associated with significantly improved one-year survival and reduced incidence of sudden death.* ***Conclusion:*** *Mortality in hemodialysis patients is strongly influenced by modifiable clinical factors, dialysis scheduling, and timing of nephrology referral. Early nephrology care and optimized dialysis planning may substantially reduce mortality and sudden death among HD patients.*

Keywords: Chronic kidney disease, early nephrology care, hemodialysis, interdialytic interval, mortality prediction model, sudden death

INTRODUCTION

Chronic kidney disease (CKD) has emerged as a major global public health challenge, characterized by progressive loss of renal function and increased morbidity and mortality. With the rising prevalence of diabetes mellitus, hypertension, and aging populations, the burden of CKD continues to escalate worldwide. For patients who progress to end-stage kidney disease (ESKD), renal replacement therapy using hemodialysis remains the most frequently and commonly utilized treatment modality, particularly in developing countries [1].

Although hemodialysis is life-sustaining, patients undergoing maintenance HD experience significantly higher mortality rates compared with

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the general population. Cardiovascular disease and sudden cardiac death account for a substantial proportion of deaths among dialysis patients. The uremic milieu, electrolyte shifts, fluid overload, autonomic dysfunction, and structural heart disease collectively contribute to this elevated risk. Despite technological advances in dialysis delivery, mortality rates among HD patients remain unacceptably high.

Sudden death in hemodialysis patients has gained increasing attention due to its unpredictable nature and devastating consequences. Evidence suggests that dialysis-related factors, including interdialytic weight gain, electrolyte fluctuations, and timing of dialysis sessions, may precipitate fatal arrhythmias. In particular, prolonged interdialytic intervals – such as the long weekend gap – have been associated with increased risk of sudden death and cardiovascular events [2].

In addition to dialysis-related factors, the timing and quality of nephrology care prior to dialysis initiation play a critical role in determining patient outcomes. Early nephrology referral enables better management of comorbidities, timely creation of vascular access, patient education, and optimization of nutritional and cardiovascular status. Conversely, late referral is often associated with emergency dialysis initiation, catheter-based access, and poor survival outcomes.

Despite recognition of these issues, there remains a lack of comprehensive studies integrating clinical risk factors, dialysis timing, and pre-dialysis nephrology care into a unified framework for mortality risk assessment. Understanding these relationships is particularly important in resource-constrained settings, where late presentation and limited access to specialized care are common.

Therefore, the present study was undertaken to systematically evaluate mortality risk factors in patients receiving maintenance hemodialysis, examine the effect of interdialytic intervals on sudden death, and assess the impact of early nephrology care on one-year mortality. The findings aim to inform evidence-based strategies for risk stratification and targeted interventions to improve survival outcomes in this vulnerable population [3].

REVIEW OF LITERATURE

Global Burden of Chronic Kidney Disease and Hemodialysis

Chronic kidney disease affects millions of individuals worldwide and is associated with significant healthcare utilization and economic burden. Epidemiological studies consistently demonstrate rising CKD prevalence, particularly in low- and middle-income countries. Hemodialysis remains the predominant renal replacement therapy due to its relative availability and lower upfront cost compared to transplantation.

Despite its widespread use, hemodialysis is associated with reduced health-related quality of life and high mortality. Long-term HD patients experience frequent hospitalizations, physical limitations, psychological distress, and social challenges, all of which contribute to adverse outcomes [4].

Mortality and Sudden Death in Hemodialysis Patients

Sudden death is one of the leading causes of mortality among patients on maintenance hemodialysis. Several studies report that sudden cardiac death accounts for nearly 25–30% of all deaths in this population. Structural heart disease, left ventricular hypertrophy, ischemic heart disease, and arrhythmogenic electrolyte shifts are commonly implicated.

Electrolyte disturbances, particularly hyperkalemia and rapid potassium shifts during dialysis, are well-recognized triggers of fatal arrhythmias. In addition, intradialytic hypotension, autonomic dysfunction, and myocardial stunning further increase cardiovascular vulnerability [5].

Interdialytic Time Interval and Mortality Risk

The timing of hemodialysis sessions has emerged as a critical determinant of patient outcomes. Studies examining interdialytic intervals consistently demonstrate higher mortality rates following

prolonged gaps between dialysis sessions, especially the long weekend interval in thrice-weekly dialysis schedules.

During extended interdialytic periods, patients accumulate excess fluid, sodium, and potassium, leading to volume overload and metabolic instability. Observational studies have shown increased rates of sudden death, cardiovascular hospitalization, and all-cause mortality during the first dialysis session following the long interval [6].

Risk Factors and Mortality Prediction Models

Numerous studies have attempted to identify predictors of mortality in HD patients, including demographic variables, comorbidities, laboratory parameters, and cardiac findings. Advanced age, diabetes mellitus, hypertension, anemia, inflammation, hypoalbuminemia, and abnormal ECG findings have been consistently associated with poor survival.

Multivariable regression models and risk scores have been developed to predict mortality; however, their applicability varies across populations. There remains a need for context-specific models incorporating dialysis-related and care-related variables.

Role of Early Nephrology Care

Early nephrology referral prior to dialysis initiation is widely recognized as a key factor influencing patient outcomes. Patients receiving timely nephrology care are more likely to initiate dialysis with permanent vascular access, achieve better metabolic control, and receive education regarding dialysis modalities.

Multiple studies have demonstrated that late referral is associated with increased mortality, higher hospitalization rates, and greater healthcare costs. Early nephrology care has also been linked to improved cardiovascular outcomes and reduced incidence of sudden death [7].

Gaps in Existing Literature

Although individual risk factors for mortality in HD patients are well documented, few studies have simultaneously evaluated clinical risk factors, interdialytic timing, and pre-dialysis care within a single cohort. Additionally, data from developing regions remain limited. Addressing these gaps is essential for designing targeted interventions and improving survival outcomes in hemodialysis populations [8].

METHODOLOGY

Study Design and Setting

This prospective observational study was conducted among adult patients receiving maintenance hemodialysis at a tertiary care center. The study included patients who initiated long-term hemodialysis during the defined study period.

Study Population

All adult patients (≥18 years) with end-stage kidney disease who commenced maintenance hemodialysis were considered eligible. Patients who underwent kidney transplantation, switched to other dialysis modalities, or were non-adherent to dialysis were excluded from the final analysis.

Data Collection

Baseline demographic data, including age and sex, were recorded. Clinical variables included comorbidities such as diabetes mellitus, hypertension, ischemic heart disease, and cerebrovascular disease. Laboratory parameters, including blood urea nitrogen, serum electrolytes, hemoglobin, and inflammatory markers, were obtained at baseline.

Electrocardiographic and echocardiographic findings were documented to assess cardiac structure and function. Dialysis-related variables, including interdialytic intervals and dialysis scheduling, were recorded.

Information regarding nephrology care prior to dialysis initiation was collected and categorized into early and late referral groups based on predefined criteria.

Outcome Measures

The primary outcomes were all-cause mortality and sudden death. Secondary outcomes included one-year survival and cause-specific mortality.

Statistical Analysis

Descriptive statistics were used to summarize baseline characteristics. Logistic regression analysis was employed to identify independent predictors of mortality and to develop a mortality prediction model. The effect of interdialytic intervals on sudden death was analyzed using time-based comparisons. Survival analysis was performed using Kaplan–Meier curves, and differences between groups were assessed using the log-rank test. A p-value <0.05 was considered statistically significant [9, 10].

RESULTS

A total of patients receiving maintenance hemodialysis were included in the final analysis. The demographic profile revealed a predominance of middle-aged and elderly individuals, with males constituting a slightly higher proportion of the study population. A significant number of patients had multiple comorbid conditions, most commonly hypertension and diabetes mellitus, followed by ischemic heart disease.

Clinical and Biochemical Characteristics

Baseline laboratory evaluation showed that many patients had anemia, electrolyte disturbances, and elevated uremic markers at the time of dialysis initiation. Hyperkalemia and fluctuations in serum sodium were frequently observed, particularly among patients with irregular dialysis attendance or prolonged interdialytic intervals. Electrocardiographic abnormalities, including prolonged QT interval and evidence of left ventricular hypertrophy, were common findings.

Echocardiographic assessment demonstrated a high prevalence of left ventricular hypertrophy and diastolic dysfunction, both of which are recognized risk factors for adverse cardiovascular outcomes in hemodialysis patients.

Mortality Outcomes

During the follow-up period, a substantial proportion of patients experienced mortality, with cardiovascular causes accounting for most of deaths. Sudden death emerged as a leading cause, occurring most frequently in patients with known cardiac disease, electrolyte imbalance, and poor dialysis adherence.

Analysis of dialysis timing revealed a clear association between prolonged interdialytic intervals and mortality. Sudden death was significantly more common during the first dialysis session following the long interdialytic gap, particularly after the weekend interval in patients receiving thrice-weekly dialysis. Patients with excessive interdialytic weight gain and elevated pre-dialysis potassium levels were at particularly high risk.

Impact of Early Nephrology Care

Patients who received early nephrology care prior to the initiation of dialysis demonstrated significantly better outcomes. These patients were more likely to initiate dialysis with permanent vascular access, had better biochemical control, and showed lower rates of emergency dialysis initiation.

One-year survival analysis revealed that patients with early nephrology referral had significantly higher survival rates compared to those referred late. The incidence of sudden death was notably lower in the early referral group, highlighting the protective role of timely nephrology involvement.

Predictors of Mortality

Multivariable logistic regression analysis identified several independent predictors of mortality. Advanced age, presence of cardiovascular comorbidities, abnormal electrolyte levels, prolonged interdialytic intervals, and late nephrology referral were significantly associated with increased mortality risk.

A mortality prediction model developed from these variables demonstrated good discriminative ability, indicating its potential usefulness in identifying high-risk patients who may benefit from targeted interventions and closer monitoring.

DISCUSSION

The findings of the present study highlight the complex interplay between clinical risk factors, dialysis-related variables, and healthcare delivery practices in determining mortality among patients receiving maintenance hemodialysis. Despite advances in dialysis technology, mortality rates remain high, underscoring the need for comprehensive risk assessment and preventive strategies.

Sudden death emerged as a major cause of mortality in this cohort, consistent with previous studies reporting a high burden of cardiovascular deaths in dialysis populations. Electrolyte disturbances, particularly hyperkalemia, and underlying structural heart disease likely contribute to fatal arrhythmias. The high prevalence of left ventricular hypertrophy observed in this study further supports the role of cardiovascular pathology in adverse outcomes.

one of the most important findings of this study is the strong association between prolonged interdialytic intervals and sudden death. The accumulation of fluid and electrolytes during extended gaps between dialysis sessions creates a vulnerable physiological state, increasing the likelihood of arrhythmias and cardiovascular instability. These findings align with existing literature and emphasize the need to reconsider dialysis scheduling and enhance monitoring during high-risk periods.

Early nephrology care was found to be a significant protective factor against mortality. Patients who received timely nephrology referral prior to dialysis initiation had better survival outcomes, fewer emergency dialysis starts, and lower rates of sudden death. Early referral allows for optimal management of comorbidities, timely vascular access creation, and patient education, all of which contribute to improved outcomes.

The mortality prediction model developed in this study integrates clinical, biochemical, and dialysis-related variables, offering a practical approach to risk stratification. Such models can assist clinicians in identifying high-risk patients and implementing individualized care plans, including more frequent monitoring, dietary counseling, and medication optimization.

From a nursing perspective, these findings reinforce the importance of continuous assessment, patient education, and early identification of warning signs. Nurses play a pivotal role in monitoring interdialytic weight gain, recognizing electrolyte imbalance symptoms, and ensuring adherence to dialysis schedules.

Despite its strengths, the study has limitations. The single-center design and relatively limited sample size may affect generalizability. Additionally, some variables relied on observational data, which may be subject to residual confounding. Future multicenter studies with larger cohorts are recommended to validate these findings and refine mortality prediction models.

CONCLUSION

Mortality among patients receiving maintenance hemodialysis remains a critical challenge, with sudden death accounting for a substantial proportion of fatalities. The present study demonstrates that mortality is strongly influenced by a combination of patient-related factors, dialysis scheduling, and the timing of nephrology care.

Prolonged interdialytic intervals were significantly associated with increased risk of sudden death, highlighting the need for careful dialysis planning and enhanced monitoring during high-risk periods. Electrolyte disturbances and cardiovascular comorbidities further compounded mortality risk, emphasizing the importance of meticulous biochemical and cardiac assessment.

Early nephrology referral emerged as a key protective factor, significantly improving one-year survival and reducing the incidence of sudden death. These findings underscore the necessity of timely nephrology involvement in the management of patients with progressive kidney disease.

The mortality prediction model developed in this study offers a useful framework for identifying high-risk patients and guiding targeted interventions. Incorporating such models into routine clinical practice may facilitate proactive care and improve patient outcomes.

Overall, the study highlights the critical role of multidisciplinary care, particularly nursing surveillance and patient education, in reducing mortality among hemodialysis patients. Strengthening early referral pathways, optimizing dialysis schedules, and implementing structured risk assessment protocols may substantially enhance survival and quality of care in this vulnerable population.

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