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Acute Complications in Hemodialysis: Frequency, Patterns, and Clinical Implications

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ABSTRACT

Chronic Kidney Disease (CKD) is a progressive and irreversible condition increasingly recognized as a global public health challenge. Hemodialysis, though life-sustaining, is frequently associated with acute complications that compromise patient outcomes and healthcare quality, especially in resource-limited settings. **Objectives:** To determine the frequency of acute complications during hemodialysis in patients with dialysis-dependent CKD at MTI Mardan Medical Complex, Mardan. **Methods:** This descriptive cross-sectional study was conducted from January to June 2025, involving 326 patients undergoing maintenance hemodialysis. Data were collected using a structured proforma documenting clinical and demographic characteristics, comorbidities, and intradialytic complications across multiple sessions. Standardized clinical definitions were applied to identify events such as hypotension (systolic BP drop ≥20 mmHg or <90 mmHg), hypoglycemia (RBS <70 mg/dL), and chest pain. The data were analyzed using SPSS version 20.0. **Results:** The mean age was 37.7 ± 12.1 years, with a male predominance (55.2%). The average duration of dialysis was 9.2 ± 5.1 months. Acute complications were observed in 41.7% of patients, with hypotension being the most frequently reported complication. **Conclusions:** Intra-dialytic complications are common in maintenance hemodialysis, with hypotension being the most prevalent. Enhanced monitoring, standardized protocols, and multicenter studies are warranted to reduce complication rates and improve patient care.

INTRODUCTION

Chronic kidney disease (CKD) is increasingly recognized as a systemic disorder rather than being confined to renal impairment alone. It affects multiple organ systems and significantly increases cardiovascular morbidity and mortality. Cardiovascular disease, including coronary artery disease, heart failure, arrhythmias, and sudden cardiac death, is the leading cause of death in CKD patients, with a risk up to tenfold higher than in the general population [1]. As CKD progresses and glomerular filtration rate (GFR) falls below 30mL/min/1.73m^2, disturbances in mineral metabolism emerge, marked by hyperphosphatemia, borderline or low serum calcium, and elevated parathyroid hormone (PTH) levels, collectively termed CKD–mineral and bone disorder (CKD–MBD) [2]. These changes manifest clinically as bone pain and muscular discomfort. Declining GFR also leads to anemia due to reduced erythropoietin production, contributing to symptoms such as exertional dyspnea, fatigue, and diminished quality of life [3]. When GFR drops below 15 mL/min/1.73 m^2, uremic complications, including anorexia,

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nausea, vomiting, dyspnea, weight loss, peripheral edema, acidosis, and cognitive impairment, become clinically significant [4]. At this advanced stage, conservative measures alone are insufficient, and renal replacement therapy (RRT) becomes necessary. Hemodialysis remains the most common modality for RRT worldwide due to its immediacy and broad clinician experience; however, it requires secure vascular access via catheters, arteriovenous fistulas, or grafts [5]. A pre-dialysis systolic blood pressure of at least 100 mmHg is typically required to ensure adequate treatment flow; whereas, hypotension is not a contraindication to peritoneal dialysis [6]. Despite its life-saving role, hemodialysis is associated with a spectrum of acute complications. These range from mild symptoms such as nausea and headache to more severe issues, including hypoglycemia, intradialytic hypotension or hypertension, hemolysis, allergic reactions, and even stroke [7]. Intradialytic hypotension, the most common complication affecting between 8% and 40% of sessions, is associated with increased cardiovascular events and mortality. It arises from excessive ultrafiltration, impaired cardiovascular compensatory mechanisms, and autonomic dysfunction, especially in elderly, diabetic, or dialysis-naïve individuals [8]. However, there exists a study gap in the regional literature documenting standardized, protocol-based evaluation of acute hemodialysis complications, especially in under-resourced healthcare settings like ours. Existing data lack uniformity in complication definitions, time points of monitoring, and interventions employed.

This study aims to assess the frequency, patterns, and clinical implications of acute complications during maintenance hemodialysis among CKD patients at Mardan Medical Complex, Mardan.

METHODS

This descriptive cross-sectional study was conducted in the Nephrology Department of Mardan Medical Complex from January to June 2025 after obtaining ethical approval from the Bacha Khan Medical College and Mardan Medical Complex, Mardan, Pakistan (Ref No: 435/BKMC). Patients aged 15–70 years undergoing maintenance hemodialysis who provided informed consent were included, while those on peritoneal dialysis, receiving blood transfusions during dialysis, or presenting with pre-existing complications were excluded. A sample size of 326 was calculated using Cochran's formula for categorical data (p=30.4%, d=5%, Z=1.96), and non-probability consecutive sampling was employed [9]. Data were collected using a structured proforma recording demographic information, comorbidities (diabetes, hypertension, cardiovascular disease), and dialysis-related details, and patients were monitored during a single dialysis session for acute complications including hypotension (SBP <90 mmHg or a drop ≥20 mmHg with/without symptoms), headache, chest pain, nausea, vomiting, fever, muscle cramps, and hypoglycemia (RBS <70 mg/dL). Complications were documented by trained nursing staff and verified by the nephrologist, while preventive or corrective interventions (IV fluids, midodrine, dialysate temperature adjustment, ultrafiltration reduction) were provided as clinically indicated but not uniformly standardized, hence excluded from final analysis. Dialysis adequacy parameters (Kt/V or URR) were not recorded, although duration in months was noted. Data were analyzed using SPSS version 20.0 with descriptive statistics (means, standard deviations, frequencies), normality tested by Shapiro–Wilk, independent sample t-test applied for continuous variables, and Chi-square test for categorical variables, with a significance level set at $p \leq 0.05$.

RESULTS

The study results demonstrated the Distribution of demographic variables (age, gender, BMI) and clinical parameters (duration of dialysis, pre-dialysis systolic blood pressure, and diabetes status), along with the proportion of patients who experienced acute complications (Table 1).

Table 1: Baseline Demographic and Clinical Characteristics of Patients Undergoing Hemodialysis (N = 326)

Variables		Frequency (%) / Mean ± SD
Mean Age (years)		37.7 ± 12.1
Gender	Male	180 (55.2%)
	Female	146 (44.8%)
Mean BMI (kg/m^2)		23.7 ± 5.17
Mean Duration of Dialysis (months)		12.6 ± 8.57
Mean Pre-Dialysis SBP (mmHg)		144.5 ± 29.8
Diabetes Mellitus		176 (53.9%)
Non-Diabetic		150 (46.1%)
Patients with Acute Complications		136 (41.7%)

The study showed the frequency of acute complications stratified by age, gender, duration of dialysis, BMI, systolic blood pressure, and diabetes status. Statistical significance ($p \leq 0.05$) is indicated by an asterisk (*), with intradialytic complications found to be significantly more common in older patients, diabetics, and those with lower BMI.

An independent sample t-test was applied for age; a Chi-square test was applied for other variables (Table 2).

Table 2: Association of Demographic and Clinical Risk Factors with Acute Complications in Hemodialysis Patients (n=326)

Risk Factor	Complication Rate (%)	p-Value
Age > 40 years	65.5	<0.00001*
Age ≤ 40 years	28.5	<0.00001*
Male	42.2	0.837
Female	41.1	0.837
>12 months dialysis	38.5	0.452

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≤12 months dialysis	43.0	0.452
BMI > 25 kg/m^2	30.0	0.004*
BMI ≤ 25 kg/m^2	46.9	0.004*
SBP > 140 mmHg	35.7	0.056
SBP ≤ 140 mmHg	46.2	0.056
Diabetic	56.8	<0.00001*
Non-Diabetic	24.0	<0.00001*

Non-Diabetic24.0<0.00001** p≤0.05 indicates statistical significance

The bar chart illustrates the distribution of acute intra-dialytic complications among 326 patients. Hypotension was the most frequently observed complication, affecting 34 patients, which accounts for 25.0% of all reported complications. Hypoglycemia followed as the second most common, with 21 instances (15.4%). Headache and Chest Pain occurred with similar frequencies, each at 18 cases (13.2%). Overall, 136 patients experienced at least one complication, representing 41.7% of the total patient group (Figure 1).

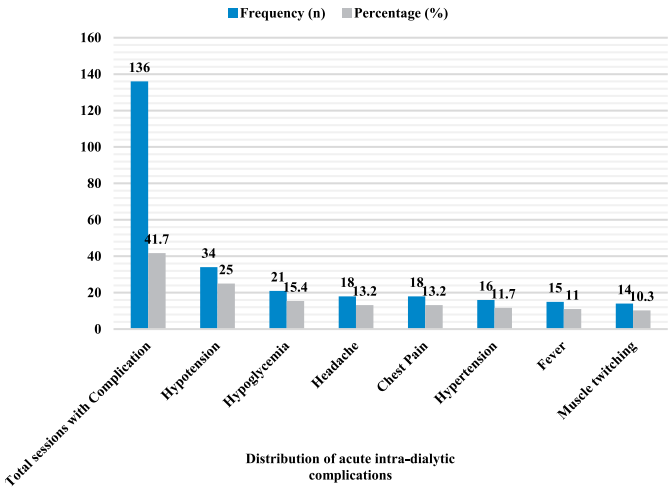

Figure 1: Distribution of Acute Intradialytic Complications Among 326 Patients

DISCUSSIONS

Chronic Kidney Disease (CKD) represents irreversible renal impairment associated with progressively worsening outcomes and systemic complications. Globally, diabetes mellitus and hypertension remain the leading causes of CKD, but nephrotoxic medications, recurrent infections, and urologic pathologies are increasingly being recognized as important contributors to renal decline [10, 11]. Additional etiologies include glomerulonephritis, interstitial nephritis, neoplasms, congenital anomalies, and obstructive uropathies [12]. Addressing the primary cause is essential to delay CKD progression and improve long-term prognosis [13]. CKD may remain clinically silent for years, particularly in cases of chronic glomerulonephritis or interstitial disease, but can also manifest as rapidly progressing renal failure, particularly in acute glomerular or obstructive pathologies [14]. Multiple studies report that most CKD patients are asymptomatic at the time of diagnosis, often identified during preoperative evaluations or anemia workups [15]. Given this, guidelines recommend annual screening for proteinuria and serum creatinine in diabetic patients above 40 years to enable early detection [16]. Proteinuria, in particular, is a reliable marker for both disease severity and prognosis [17]. CKD is stratified into five stages based on glomerular filtration rate (GFR), with stage G5 representing end-stage renal disease (ESRD), necessitating renal replacement therapy [18]. In Pakistan, hemodialysis remains the primary modality due to widespread availability and greater patient compliance compared to peritoneal dialysis [19]. Unfortunately, more than 95% of patients begin hemodialysis via temporary double-lumen catheters, often under emergency conditions [20]. Hemodialysis provides symptomatic relief, particularly from dyspnea, uremia, acidosis, and anorexia, but is also associated with various complications [21]. In the current study, acute intra-dialytic complications were observed in 41.7% of patients, a rate higher than seen in comparable international studies [22]. These complications, especially when frequent, contribute to reduced dialysis adherence, poor quality of life, and increased morbidity [23]. The most prevalent complication was intradialytic hypotension, which aligns with global findings and is often attributed to autonomic dysfunction, reduced cardiac reserve, and aggressive fluid removal strategies [24]. Our study showed that hypotension was more prevalent in patients with low BMI and in those with diabetes as the underlying cause of CKD, both of which are known risk factors for hemodynamic instability during dialysis. Interestingly, dialysis duration did not significantly affect complication frequency. Whether patients were on dialysis for less or more than 12 months, the incidence of acute complications remained comparable, suggesting that risk persists regardless of dialysis vintage. Gender also did not show a statistically significant correlation, with similar complication rates in males and females. Age, however, emerged as a significant factor. Patients older than 40 years had a higher incidence of complications, possibly due to increased vascular stiffness, subclinical atherosclerosis, and higher inflammatory markers typical of aging. Comorbidities such as coronary artery disease, osteoarthritis, and polypharmacy may further exacerbate this risk. Given these findings, routine pre-dialysis assessments should be intensified for diabetic patients and those above 40 years of age. Regular monitoring for early signs of intradialytic complications can guide timely interventions, improving patient safety and outcomes. Future prospective, multi-center studies are warranted to explore the

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pathophysiological links between aging, diabetes, and hemodialysis-associated complications to develop effective preventive strategies. Our study has several limitations. First, complications were recorded during a single dialysis session per patient, which may not fully represent their overall intradialytic experience. Second, although complications were defined using widely accepted clinical thresholds (e.g., systolic BP drop >20 mmHg for hypotension), a standardized documentation checklist was not used, which may have introduced variability in recognition or recording of events. Third, preventive or corrective measures such as fluid boluses, midodrine administration, or dialysate temperature adjustments were applied as per routine care but were not uniformly recorded or analyzed. Finally, dialysis adequacy indicators such as Kt/V or URR were not included, which might have influenced complication rates and limits our ability to correlate outcomes with session effectiveness.

CONCLUSIONS

This study highlights that acute complications during hemodialysis are frequent, with intradialytic hypotension emerging as the most common event. Older age, diabetes mellitus, and low body mass index were identified as significant risk factors. These findings emphasize the need for careful pre-dialysis risk assessment and individualized management, particularly in high-risk patients. Strengthening early detection and timely intervention can improve safety and treatment outcomes. Larger multicenter studies are warranted to develop standardized preventive protocols and optimize care in dialysis populations.

Authors Contribution

Conceptualization: MNS,
Methodology: MWS, MM, YA
Formal analysis: ZU
Writing review and editing: AK

All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

All the authors declare no conflict of interest.

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