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Original Article

Spectrum of Intradialytic Complications in End-Stage Renal Disease Patients on Maintenance Hemodialysis

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ABSTRACT

Background: End-stage renal disease (ESRD) is a growing public health challenge in low- and middle-income countries, including Pakistan, where hemodialysis remains the predominant renal replacement therapy. Although lifesaving, hemodialysis is frequently associated with intradialytic complications that impair treatment safety and outcomes. Objective: To determine the frequency and spectrum of intradialytic complications in ESRD patients undergoing maintenance hemodialysis and to identify demographic and clinical factors associated with their occurrence. Methods: A cross-sectional study was conducted at Khyber Teaching Hospital, Peshawar, between October 2024 and March 2025. Eighty-two patients aged 18–70 years on maintenance hemodialysis for at least three months were recruited by consecutive sampling. Data were collected on demographics, comorbidities, vascular access, and laboratory parameters. Complications were defined using standardized criteria. Statistical analyses included chi-square, Fisher's exact, and t-tests, with $p \leq 0.05$ considered significant. Results: Ninety-three complication events were observed among 82 patients. Hypotension (29.3%) was most common, followed by hypertension (17.1%), back pain (14.6%), and nausea/vomiting (12.2%). Less frequent events included infections (8.5%), cramps (8.5%), and chest pain (7.3%). Female patients ($p = 0.0046$) and those with dialysis vintage ≥2 years ($p < 0.001$) had significantly higher complication rates, while age, vascular access, dialysis frequency, and session length showed no significant associations. Conclusion: Intradialytic complications are frequent among ESRD patients, with hypotension the most prevalent. Female sex and longer dialysis duration independently increased risk, underscoring the need for targeted preventive strategies to improve hemodialysis safety.

Keywords: End-stage renal disease; Hemodialysis; Intradialytic complications; Hypotension; Pakistan.

INTRODUCTION

Chronic kidney disease (CKD) has emerged as a major global health problem, affecting more than 10% of the adult population worldwide, with prevalence steadily increasing due to rising rates of diabetes, hypertension, and aging populations (1). CKD is defined by either evidence of kidney damage or a sustained reduction in estimated glomerular filtration rate (eGFR) below 60 ml/min/1.73 m² for at least three months, irrespective of cause (2). The etiology is multifactorial, with diabetes mellitus and hypertension contributing the greatest burden, followed by glomerulonephritis, polycystic kidney disease, and other secondary causes (3). The Global Burden of Disease study highlighted a significant increase in morbidity and mortality attributable to CKD, particularly in low- and middle-income countries (4). In Pakistan, the CKD prevalence has escalated in parallel with the diabetes and hypertension epidemics, compounded by socioeconomic disparities and limited healthcare access, which contribute to delayed diagnosis and poor outcomes (5,6).

End-stage renal disease (ESRD), the most advanced stage of CKD, necessitates renal replacement therapy, with hemodialysis being the predominant modality in many regions due to limited transplantation facilities. Hemodialysis involves extracorporeal filtration of blood through a dialyzer, which effectively removes metabolic waste and excess fluid. Despite being lifesaving, the procedure is frequently associated with intradialytic complications that compromise treatment efficacy and patient safety (7). These complications encompass a wide range of clinical manifestations, including hypotension, arrhythmias, vascular access issues, electrolyte imbalances, and infections, all of which contribute to increased morbidity, hospitalization, and mortality in ESRD patients (8,9).

Several studies have investigated intradialytic complications in different populations, though findings vary by geographic and demographic context. For instance, Ali et al. reported hypotension as the most frequent complication (28.7%), followed by hypertension (17%) and nausea/vomiting (11.7%) in a Pakistani cohort (10). Similarly, Raja et al. documented a 30.7% complication rate among patients undergoing twice-weekly dialysis in Eritrea, with hypotension and nausea/vomiting being most prevalent (11). However, the spectrum and frequency of complications differ across studies, partly due to variations in dialysis practices, patient characteristics, and healthcare

infrastructure. Importantly, there is a paucity of local evidence in Pakistan specifically addressing intradialytic complications, with existing studies limited by small sample sizes and lack of stratification by demographic and clinical variables.

Given the high prevalence of ESRD in Pakistan and the diverse demographic and genetic profile of affected patients, understanding the specific burden and determinants of intradialytic complications is essential. Such evidence can guide nephrologists in implementing targeted preventive measures, optimizing dialysis care, and reducing the risk of morbidity and mortality. Furthermore, identifying associations with demographic and clinical parameters such as gender, dialysis vintage, and comorbidities can inform individualized patient management and resource allocation.

The objective of this study was therefore to determine the frequency and spectrum of intradialytic complications among ESRD patients undergoing maintenance hemodialysis at a tertiary care hospital in Pakistan, and to assess their association with demographic and clinical characteristics.

MATERIAL AND METHODS

This cross-sectional observational study was conducted in the Department of Nephrology, Khyber Teaching Hospital, Peshawar, Pakistan, between October 1, 2024, and March 31, 2025, Consecutive sampling was employed to recruit participants who met the eligibility criteria. The study population comprised adult patients aged 18 to 70 years, of both sexes, diagnosed with end-stage renal disease (ESRD) and undergoing maintenance hemodialysis two or three times per week for at least three months. Exclusion criteria included patients receiving dialysis for acute kidney injury, those requiring emergency dialysis for toxicological or metabolic emergencies, patients in the initial three months of dialysis initiation, and pregnant women. This approach ensured enrollment of a stable ESRD cohort and minimized confounding by transient or acute renal conditions.

Sample size was calculated using the WHO sample size calculator (version 1.1), applying a 95% confidence interval, 4.6% absolute precision, and an anticipated prevalence of 4.71% for muscular cramps derived from prior literature (11). Based on these parameters, the final sample size was 82 participants.

Recruitment was carried out in both the in-patient nephrology unit and the outpatient hemodialysis unit. Eligible patients were identified from hospital records and dialysis registers, and informed consent was obtained after detailed explanation of study objectives, procedures, and confidentiality assurances. All participants underwent structured interviews and clinical examination, and data were collected using a pre-designed proforma. Demographic information, medical history, comorbidities, socioeconomic status, and lifestyle factors such as smoking were documented. Pre-dialysis and post-dialysis laboratory values, including serum electrolytes (sodium, potassium, calcium, phosphate), glucose, hemoglobin, and parathyroid hormone levels, were recorded. Dialysis adequacy was assessed using urea reduction ratio and single-pool Kt/V.

Intradialytic complications were defined and recorded according to standardized clinical and laboratory criteria. Hypotension was defined as a systolic blood pressure drop to <90 mmHg or a decrease ≥30 mmHg from baseline during dialysis. Hypertension was considered when systolic blood pressure exceeded 160 mmHg during the session. Muscle cramps were defined as painful involuntary muscle contractions requiring intervention. Hypoglycemia was documented when random blood glucose was <70 mg/dL. Dialysis-related infections were identified by fever, chills, vascular access site inflammation, or positive blood culture within 24 hours of treatment. Dialysis disequilibrium syndrome was diagnosed when patients exhibited neurological symptoms, such as confusion or seizures, within 24 hours post-session. Other complications, including chest pain, arrhythmia, itching, and dialyzer reaction, were identified using patient-reported symptoms and clinical assessments corroborated by ECG or laboratory findings.

Data integrity was maintained by double-entry of records into a secure database and cross-verification with medical charts. To minimize bias, data collection was standardized, and all investigators received uniform training on definitions and procedures. Observer agreement was checked intermittently to ensure reliability in documenting complications. Statistical analysis was performed using SPSS version 25. Continuous variables were assessed for normality using the Shapiro–Wilk test. Normally distributed variables were expressed as mean ± standard deviation, while non-normally distributed data were presented as median with interquartile ranges. Categorical variables were reported as frequencies and percentages. Associations between categorical variables and complications were assessed using chi-square test or Fisher's exact test, while independent t-tests were applied for continuous variables. A p-value ≤0.05 was considered statistically significant. Subgroup analyses included stratification by age, sex, vascular access type, dialysis frequency, duration of ESRD, and dialysis vintage to identify modifying effects. Missing data were handled using case-wise deletion without imputation.

The study was approved by the Institutional Research Board (IRB) of Khyber Teaching Hospital, Peshawar, and conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants or their legal guardians. Data confidentiality was ensured, and identifiers were removed from the dataset prior to analysis to protect participant privacy (13).

RESULTS

Among the 82 patients included in the study, a total of 93 intradialytic complications were documented, as several patients experienced more than one event. Hypotension was the most common complication, affecting 24 patients (29.3%), followed by hypertension in 14 (17.1%) and musculoskeletal symptoms such as back pain in 12 (14.6%). Gastrointestinal manifestations including nausea and vomiting were reported by 10 patients (12.2%). Infectious complications occurred in 7 patients (8.5%), which was equal in frequency to muscle cramps (8.5%). Chest pain was reported by 6 patients (7.3%), while pruritus was noted in 3 (3.7%). Severe but less common events included hypoglycemia (2.4%), arrhythmia (2.4%), dialyzer reactions (2.4%), seizures (2.4%), and rare cases of bleeding and dialysis

disequilibrium syndrome (1.2% each). These data confirm that hemodynamic instability and musculoskeletal complaints represent the predominant burden of intradialytic complications, while life-threatening events were infrequent.

Stratified analyses further elucidated significant predictors of complications. Female patients were disproportionately affected, with 25 of 28 women (89.3%) experiencing at least one complication compared to 30 of 54 men (55.6%), yielding a statistically significant association ($p = 0.0046$). Dialysis vintage was also strongly correlated, as 58 of 62 patients (93.5%) with ≥2 years on dialysis developed complications, compared to only 10 of 20 patients (50.0%) with a duration <2 years ($p < 0.001$). These findings suggest that both sex and treatment exposure are key determinants of complication risk.

Table 1. Frequency of Intradialytic Complications (n = 82)

Complication	Frequency (n)	Percentage (%)
Hypotension	24	29.3
Hypertension	14	17.1
Back pain	12	14.6
Nausea/vomiting	10	12.2
Dialysis-related infection	7	8.5
Muscle cramps	7	8.5
Chest pain	6	7.3
Itching	3	3.7
Hypoglycemia	2	2.4
Arrhythmia	2	2.4
Dialyzer reaction	2	2.4
Seizures	2	2.4
Bleeding	1	1.2
Dialysis disequilibrium syndrome	1	1.2

Table 2. Stratified Analysis of Intradialytic Complications

Variable	With Complications n (%)	Without Complications n (%)	p-value
Gender			0.0046
Male (n = 54)	30 (55.6)	24 (44.4)	
Female (n = 28)	25 (89.3)	3 (10.7)	
Duration since dialysis initiation			<0.001
< 2 years (n = 20)	10 (50.0)	10 (50.0)	
≥ 2 years (n = 62)	58 (93.5)	4 (6.5)	
Age group			>0.05
< 50 years (n = 40)	30 (75.0)	10 (25.0)	
≥ 50 years (n = 42)	32 (76.2)	10 (23.8)	
Duration of disease			>0.05
< 3 years (n = 30)	18 (60.0)	12 (40.0)	
≥ 3 years (n = 52)	45 (86.5)	7 (13.5)	
Type of vascular access			>0.05
AV fistula (n = 62)	40 (64.5)	22 (35.5)	
Others (n = 20)	18 (90.0)	2 (10.0)	
Dialysis frequency			>0.05
Twice weekly (n = 44)	28 (63.6)	16 (36.4)	
Thrice weekly (n = 38)	34 (89.5)	4 (10.5)	
Session duration			>0.05
≤ 4 hours (n = 50)	30 (60.0)	20 (40.0)	
> 4 hours (n = 32)	28 (87.5)	4 (12.5)	

Other clinical and demographic variables showed no significant associations with complication rates. Age stratification revealed nearly identical frequencies, with 75.0% of patients under 50 years and 76.2% of those aged ≥50 years experiencing complications ($p > 0.05$). Similarly, the duration of underlying kidney disease did not influence outcomes; 60.0% of patients with disease duration <3 years and 86.5% with longer disease duration developed complications, though this difference was not statistically significant ($p > 0.05$). The type of vascular access also showed no impact, with complication frequencies of 64.5% in patients with arteriovenous fistulas and 90.0% in those with other access modalities ($p > 0.05$). Dialysis frequency was likewise unrelated, as 63.6% of twice-weekly and 89.5% of thrice-weekly patients developed complications ($p > 0.05$). Finally, session length showed no significant relationship; complications occurred in 60.0% of patients dialyzed for ≤4 hours and in 87.5% of those dialyzed longer than 4 hours ($p > 0.05$).

Taken together, these results highlight hypotension as the leading complication during hemodialysis and identify female gender and prolonged dialysis exposure as independent risk factors. Other demographic and clinical factors, including age, vascular access type, dialysis schedule, and disease duration, did not significantly influence complication rates in this cohort.

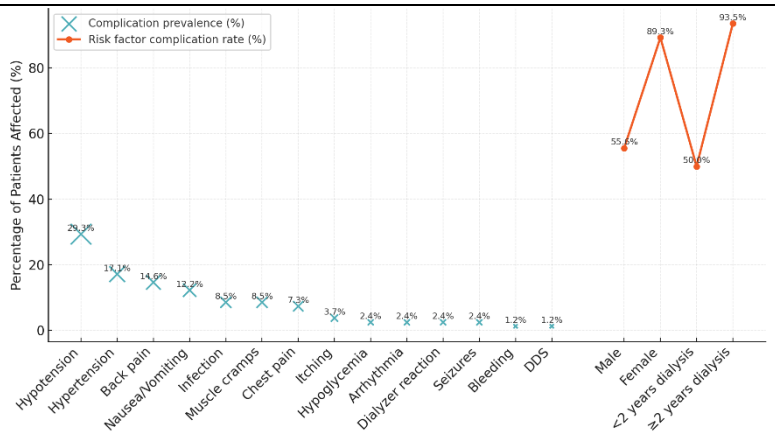

Figure 1 Distribution of Intradialytic Complications and Risk Factor Associations

The integrated visualization illustrates two key findings. First, among specific complications, hypotension was most prevalent, affecting 29.3% of patients, followed by hypertension (17.1%), back pain (14.6%), and nausea/vomiting (12.2%), with progressively lower frequencies for infections, cramps, and chest pain. Rare complications such as arrhythmia, seizures, and bleeding affected fewer than 3% of patients. Second, when stratified by risk factors, complication rates were disproportionately higher among females (89.3%) compared with males (55.6%) and in patients on dialysis for ≥2 years (93.5%) compared with those with shorter dialysis exposure (50.0%). The combined plot highlights that while hypotension and hypertension dominate the complication spectrum, long dialysis vintage and female sex are strong predictors of overall complication burden, underscoring their clinical relevance.

DISCUSSION

The present study assessed the frequency and spectrum of intradialytic complications among patients undergoing maintenance hemodialysis in a tertiary care center in Pakistan. Our findings demonstrate that nearly three-quarters of patients experienced at least one complication, with hypotension (29.3%) emerging as the most prevalent, followed by hypertension (17.1%), back pain (14.6%), and nausea or vomiting (12.2%). These results align with previous local and international studies that consistently identify hemodynamic instability as the leading adverse event during dialysis (14–16). The predominance of hypotension may be explained by multifactorial mechanisms, including excessive ultrafiltration, reduced cardiac reserve, impaired vascular tone, and inappropriate antihypertensive medication use prior to dialysis (17).

The frequency of intradialytic hypotension observed in our study was comparable to that reported by Ali et al. (28.7%) in a Pakistani cohort (10) and higher than the 12% pooled prevalence in a systematic review from Europe (16). The higher rates seen in our population may reflect delayed initiation of dialysis, suboptimal ultrafiltration practices, and a high prevalence of comorbid cardiovascular disease. Conversely, hypertension was identified as the second most frequent complication (17.1%), which contrasts with some regional studies reporting substantially lower rates of 3–8% (14,19). The higher prevalence in our cohort may be attributable to fluid overload, inadequate interdialytic weight management, and insufficient antihypertensive therapy adjustment. Importantly, intradialytic hypertension has been associated with increased mortality and hospitalization in randomized trial data (18), underscoring the clinical significance of this complication in our patients.

Musculoskeletal and gastrointestinal complications, including back pain (14.6%), muscle cramps (8.5%), and nausea/vomiting (12.2%), were relatively frequent in our cohort. These findings are consistent with earlier South Asian reports that documented musculoskeletal symptoms in approximately 10% of patients and gastrointestinal disturbances in 5–15% (11,20). The relatively high frequency of back pain observed here may be explained by prolonged immobilization and underlying mineral bone disorders, as indicated by elevated parathyroid hormone levels. Infectious complications were identified in 8.5% of patients, which corresponds with the range reported in Pakistani and Indian studies (14,21). Although the frequency was modest, dialysis-related infections remain clinically important given their potential to cause sepsis, hospitalization, and vascular access loss.

Rare but serious complications, including arrhythmias (2.4%), seizures (2.4%), and dialysis disequilibrium syndrome (1.2%), were observed. While infrequent, their presence highlights the need for careful cardiovascular monitoring and gradual dialysis initiation in patients with advanced uremia or high-risk profiles. The occurrence of chest pain in 7.3% of patients was higher than previously reported in Pakistani cohorts, where rates ranged from 0.9% to 1.5% (14,19), possibly reflecting a higher prevalence of ischemic heart disease in our population.

Stratified analyses revealed female sex and longer dialysis vintage as significant predictors of complication burden. Female patients had a markedly higher rate of complications (89.3%) compared to males (55.6%, $p = 0.0046$). This association has been inconsistently reported in literature; however, hormonal influences on vascular tone, differences in body fluid distribution, and higher prevalence of anemia in women may contribute to their increased vulnerability (22). Dialysis vintage was also strongly associated, with 93.5% of patients dialyzed for ≥2 years experiencing complications compared to 50.0% of those with shorter treatment duration ($p < 0.001$). Prolonged exposure to hemodialysis has been linked with progressive cardiovascular remodeling, chronic inflammation, and vascular calcification, which

cumulatively increase the risk of complications (23). These findings underscore the importance of close monitoring and preventive interventions in high-risk subgroups.

Strengths of the present study include a well-defined ESRD cohort, rigorous documentation of complications using standardized definitions, and stratified analysis across key demographic and clinical variables. Nonetheless, several limitations must be acknowledged. The single-center design and modest sample size may limit generalizability to broader populations. The cross-sectional nature of the study restricts causal inference, and the reliance on clinical observation without continuous biochemical or hemodynamic monitoring may have led to underreporting or misclassification of certain events. Despite these limitations, the study contributes important local evidence on intradialytic complication patterns in Pakistan, where data remain scarce.

In clinical practice, our findings emphasize the need for enhanced surveillance of hemodialysis patients, particularly women and those with prolonged dialysis exposure. Preventive strategies such as optimizing ultrafiltration rates, adjusting antihypertensive medication timing, improving nutritional management, and implementing individualized fluid balance monitoring may reduce complication rates. Additionally, education of patients regarding early recognition of symptoms and timely reporting could further mitigate adverse outcomes. At the policy level, incorporating these findings into local dialysis protocols and national guidelines could improve treatment safety and long-term outcomes for patients with ESRD in resource-limited settings.

CONCLUSION

In this cross-sectional study of patients with end-stage renal disease on maintenance hemodialysis, intradialytic complications were frequent, with hypotension representing the most common adverse event, followed by hypertension, musculoskeletal discomfort, and gastrointestinal symptoms. Female patients and those with longer dialysis exposure were identified as high-risk groups, whereas age, underlying disease duration, vascular access type, dialysis frequency, and session length did not show significant associations. These findings highlight the importance of targeted preventive strategies, such as individualized ultrafiltration management and closer monitoring of vulnerable patients, to enhance treatment safety. At a broader level, the results underscore the need for strengthening hemodialysis care protocols in Pakistan and support future multicenter and longitudinal studies to further define risk factors and optimize patient outcomes.

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