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FREQUENCY, PATTERN, AND ASSOCIATED FACTORS OF INTRADIALYTIC COMPLICATIONS AMONG PATIENTS UNDERGOING HEMODIALYSIS: A CROSS-SECTIONAL STUDY

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ABSTRACT **Background:** Intradialytic complications remain an important concern during hemodialysis and may affect treatment tolerance and completion. Their occurrence may vary according to the underlying renal disease, comorbidities, and clinical and biochemical status of the patient.**Objective:** To determine the frequency and pattern of intradialytic complications among patients undergoing hemodialysis and to evaluate their association with selected clinical and biochemical factors.**Methods:** This hospital-based observational cross-sectional study included 190 patients with chronic kidney disease (CKD) or acute kidney injury (AKI) undergoing hemodialysis at Amaltas Institute of Medical Sciences, Dewas, Madhya Pradesh, India, from October 2023 to March 2026. Patients were monitored for predefined intradialytic complications, their timing, management, and dialysis outcome. Associations with renal diagnosis, diabetes mellitus, hypertension, hemoglobin, blood urea, and serum creatinine were analyzed. A p-value <0.05 was considered statistically significant.**Results:** Intradialytic complications occurred in 122 (64.2%) of the 190 patients. Among patients who developed complications, hypotension was the most frequent event (45.1%), followed by muscle cramps (21.3%) and hypertension (16.4%). Complications occurred most commonly during the mid-session period (42.6%). The frequency of intradialytic complications was significantly higher among patients with AKI than among those with CKD (78.9% vs 60.5%; p=0.034), among patients with diabetes mellitus than those without diabetes (76.7% vs 53.8%; p=0.001), and among patients with hypertension than those without hypertension (75.0% vs 51.2%; p<0.001). Patients who developed complications had significantly lower mean hemoglobin levels (8.6 ± 1.2 vs 9.8 ± 1.4 g/dL; p<0.001) and higher mean blood urea (168 ± 42 vs 142 ± 36 mg/dL; p<0.001) and serum creatinine levels (7.8 ± 2.1 vs 6.5 ± 1.8 mg/dL; p<0.001). Overall, 74.7% of dialysis procedures were completed successfully.**Conclusion:** Intradialytic complications were frequent among patients undergoing hemodialysis, with hypotension being the most common event. Their occurrence was significantly associated with underlying renal diagnosis, diabetes mellitus, hypertension, lower hemoglobin levels, and higher blood urea and serum creatinine levels. Early identification of patients with these clinical and biochemical characteristics, together with close monitoring during hemodialysis, may facilitate timely recognition and management of intradialytic complications.

KEYWORDS : Hemodialysis; intradialytic complications; intradialytic hypotension; chronic kidney disease; acute kidney injury; anemia.

INTRODUCTION

Chronic kidney disease (CKD) has emerged as a major global public health problem. The Global Burden of Disease Study estimated that CKD accounted for approximately 35.8 million disability-adjusted life-years worldwide in 2017. [1] Progressive deterioration of kidney function may ultimately lead to kidney failure requiring renal replacement therapy in the form of hemodialysis, peritoneal dialysis, or kidney transplantation. CKD is also frequently accompanied by cardiovascular disease, anemia, electrolyte disturbances, and other complications. [2]

Hemodialysis remains one of the most widely used renal replacement modalities for patients with kidney failure and is also required in selected patients with severe acute kidney injury (AKI). It removes accumulated metabolic waste products and excess fluid and helps restore fluid, electrolyte, and acid–base balance. It principally works through diffusion and ultrafiltration across a semipermeable membrane. [3] In technology, vascular access, dialysers, and treatment protocols, maintaining physiological stability throughout a dialysis session remains an important clinical challenge. [4]

The rapid removal of fluid and solutes during hemodialysis produces substantial changes in intravascular volume, electrolyte concentrations, and cardiovascular function. [3] When compensatory mechanisms are unable to adapt adequately to these changes, patients may develop intradialytic complications. This includes hypotension, hypertension, muscle cramps, nausea, vomiting, headache, chest discomfort, and other symptoms that can affect tolerance and completion of dialysis. [4]

Among these complications, intradialytic hypotension (IDH) is particularly important because a fall in circulating volume during ultrafiltration may compromise tissue perfusion when cardiovascular compensation is inadequate. [5] Intradialytic hypotension remains common in maintenance hemodialysis populations and is influenced by patient characteristics and dialysis-related factors. [6] Intradialytic hypertension represents another clinically relevant hemodynamic disturbance. It is characterized by a paradoxical increase in blood pressure during or immediately following dialysis and may be related to volume overload. [7] It can also increase vascular resistance, endothelial dysfunction, and alterations in sodium balance. [8] Dialysate sodium concentration can influence thirst, interdialytic weight gain, fluid removal requirements, and intradialytic hemodynamic stability. This highlights the importance of an individualised dialysis prescription. [9]

Considering the clinical importance of intradialytic complications and the variability in patient- and dialysis-related factors, evaluation of their frequency and pattern in individual healthcare settings remains relevant. Therefore, the present study was undertaken to determine the frequency and pattern of intradialytic complications among patients undergoing hemodialysis and to evaluate their association with relevant clinical and biochemical factors.

MATERIALS AND METHODS

This hospital-based observational cross-sectional study was conducted in the Department of General Medicine, Amaltas Institute of Medical Sciences, Dewas, Madhya Pradesh, India, from October 2023 to March 2026. The primary objective was to determine the frequency and pattern of intradialytic complications among patients undergoing hemodialysis. The secondary objective was to assess their association with selected clinical and biochemical factors. The study included patients with chronic kidney disease (CKD) or acute kidney injury (AKI) undergoing hemodialysis in the institutional dialysis unit. Patients aged >13 years were eligible for inclusion. Pregnant women and patients aged <13 years were excluded. A total of 190 patients, as predefined in the study protocol, were enrolled using a non-probability consecutive sampling technique. Eligible patients were recruited consecutively until the required sample was achieved.

Following enrolment, demographic and clinical information was recorded using a predesigned study proforma. A detailed clinical history was obtained, followed by general and systemic examination. The information collected included age, sex, underlying renal diagnosis (CKD or AKI), associated comorbidities, indication for hemodialysis, type of vascular access. Relevant laboratory

parameters included haemoglobin, blood urea, and serum creatinine.

The patient was considered the unit of analysis, and the occurrence of at least one predefined event was considered an intradialytic complication. More than one type of complication could occur in the same patient. All observed events were recorded. Intradialytic hypotension was defined as a decrease in systolic blood pressure of ≥20 mmHg or a symptomatic fall in blood pressure during hemodialysis. Intradialytic hypertension was defined as an increase in systolic blood pressure of ≥10 mmHg during hemodialysis. Muscle cramps were defined as painful involuntary muscle contractions occurring during the dialysis session.

Among patients who developed complications, the type and timing of the events were documented. The timing was categorized as early (<1 hour), mid-session, or late (>2 hours). Management included reduction of ultrafiltration, administration of intravenous fluids, medications, oxygen therapy, and discontinuation of dialysis. More than one intervention could be required in the same patient. Dialysis outcome was recorded as successful completion, stabilization following intervention, or interruption of dialysis.

Data were entered into Microsoft Excel and analyzed using jamovi statistical software. Categorical variables were presented as frequencies and percentages, while continuous variables were expressed as mean ± standard deviation. Associations between categorical variables and the occurrence of intradialytic complications were assessed using Pearson's chi-square test. Continuous variables, including hemoglobin, blood urea, and serum creatinine, were compared between patients with and without intradialytic complications using the independent-samples Student's t-test. All statistical tests were two-sided, and a p-value <0.05 was considered statistically significant.

RESULTS

A total of 190 patients undergoing hemodialysis were included in the study. The largest proportion of patients belonged to the 51–60-year age group (27.4%). Males constituted 62.1% of the study population. Chronic kidney disease (CKD) was the underlying diagnosis in 152 (80.0%) patients, while 38 (20.0%) had acute kidney injury (AKI). Hypertension (54.7%) and diabetes mellitus (45.3%) were the most common comorbidities. Uremia was the leading indication for hemodialysis (41.1%), followed by fluid overload (22.1%) and hyperkalemia (18.9%). An arteriovenous (AV) fistula was the most frequently used vascular access (58.9%). The baseline demographic and clinical characteristics of the study population are summarized in Table 1.

Table 1. Baseline demographic and clinical characteristics of the study population (n=190)

Characteristic	n (%)
Age group (years)	
<30	18 (9.5)
31–40	32 (16.8)
41–50	46 (24.2)
51–60	52 (27.4)
>60	42 (22.1)
Male sex	118 (62.1)
Diagnosis	
CKD	152 (80.0)
AKI	38 (20.0)
Comorbidities*	
Hypertension	104 (54.7)
Diabetes mellitus	86 (45.3)
Coronary artery disease	28 (14.7)
Indication for hemodialysis	
Uremia	78 (41.1)
Fluid overload	42 (22.1)
Hyperkalemia	36 (18.9)
Metabolic acidosis	24 (12.6)
Others	10 (5.3)
Vascular access	
AV fistula	112 (58.9)
Temporary catheter	58 (30.5)
Permanent catheter	20 (10.5)

*Multiple comorbidities could be present in the same patient.

CKD: chronic kidney disease; **AKI:** acute kidney injury; **AV:** arteriovenous.

Overall, 122 (64.2%) patients experienced at least one intradialytic complication. Among the 122 affected patients, hypotension was the most frequent complication (45.1%), followed by muscle cramps (21.3%) and hypertension (16.4%). Nausea and vomiting occurred in 14.8% and 13.1% of affected patients, respectively. Headache, fever, chest pain, rigors/chills, arrhythmia, dialysis disequilibrium syndrome, and allergic reactions were less frequent. The distribution of individual intradialytic complications is presented in Table 2.

Table 2. Pattern of intradialytic complications among affected patients (n=122)

Intradialytic complication	n (%)
Hypotension	55 (45.1)
Muscle cramps	26 (21.3)
Hypertension	20 (16.4)
Nausea	18 (14.8)
Vomiting	16 (13.1)
Headache	12 (9.8)
Fever	10 (8.2)
Chest pain	9 (7.4)
Rigors/chills	8 (6.6)
Arrhythmia	7 (5.7)
Dialysis disequilibrium syndrome	5 (4.1)
Allergic reaction	4 (3.3)

*Multiple complications could occur in the same patient; therefore, percentages do not total 100%.

With respect to timing, intradialytic complications occurred most frequently during the mid-session period (42.6%), followed by the early phase (<1 hour; 31.1%) and late phase (>2 hours; 26.3%). Reduction of ultrafiltration was the most frequently required intervention (39.3%), followed by intravenous fluids (32.8%) and medications (29.5%). Dialysis had to be stopped in 18.0% of patients with complications, while oxygen therapy was required in 14.8%. Overall, 142 (74.7%) dialysis sessions were completed successfully, 28 (14.7%) required stabilization following intervention, and 20 (10.5%) were interrupted. The timing, management, and outcomes of intradialytic complications are summarized in Table 3.

Table 3. Timing, management, and outcome of intradialytic complications

Parameter	n (%)
Timing of complications (n=122)	
Early (<1 hour)	38 (31.1)
Mid-session	52 (42.6)
Late (>2 hours)	32 (26.3)
Management (n=122)*	
Ultrafiltration reduced	48 (39.3)
IV fluids	40 (32.8)
Medications	36 (29.5)
Dialysis stopped	22 (18.0)
Oxygen therapy	18 (14.8)
Dialysis outcome (n=190)	
Completed successfully	142 (74.7)
Stabilized after intervention	28 (14.7)
Interrupted	20 (10.5)

*More than one intervention could be required in the same patient; therefore, management percentages do not total 100%.

Intradialytic complications were significantly more frequent among patients with AKI than among those with CKD (78.9% vs 60.5%; p=0.034). The occurrence of complications was also significantly higher among patients with diabetes mellitus (76.7% vs 53.8%; p=0.001) and hypertension (75.0% vs 51.2%; p<0.001) compared with those without these comorbidities.

Significant differences were also observed in the biochemical parameters. Patients who developed intradialytic complications had lower mean hemoglobin levels than those without complications (8.6 ±

1.2 vs 9.8 ± 1.4 g/dL; p<0.001). In contrast, mean blood urea (168 ± 42 vs 142 ± 36 mg/dL; p<0.001) and serum creatinine levels (7.8 ± 2.1 vs 6.5 ± 1.8 mg/dL; p<0.001) were significantly higher among patients who developed complications. The clinical and biochemical factors associated with intradialytic complications are summarized in Table 4.

Table 4. Clinical and biochemical factors associated with intradialytic complications

Factor	Complication present (n=122)	Complication absent (n=68)	p-value
Renal diagnosis			0.034
CKD (n=152)	92 (60.5%)	60 (39.5%)	
AKI (n=38)	30 (78.9%)	8 (21.1%)	
Diabetes mellitus			0.001
Present (n=86)	66 (76.7%)	20 (23.3%)	
Absent (n=104)	56 (53.8%)	48 (46.2%)	
Hypertension			<0.001
Present (n=104)	78 (75.0%)	26 (25.0%)	
Absent (n=86)	44 (51.2%)	42 (48.8%)	
Hemoglobin (g/dL), mean ± SD	8.6 ± 1.2	9.8 ± 1.4	<0.001
Blood urea (mg/dL), mean ± SD	168 ± 42	142 ± 36	<0.001
Serum creatinine (mg/dL), mean ± SD	7.8 ± 2.1	6.5 ± 1.8	<0.001

Abbreviations: CKD, chronic kidney disease; AKI, acute kidney injury; SD, standard deviation.

Statistical tests: Pearson's chi-square test was used for categorical variables and the independent-samples Student's *t*-test for continuous variables. A p-value <0.05 was considered statistically significant.

DISCUSSION

The present study evaluated the frequency, pattern, and associated factors of intradialytic complications among 190 patients undergoing hemodialysis. Nearly two-thirds of the patients (64.2%) experienced at least one intradialytic complication. Hypotension was the most frequent complication, followed by muscle cramps and hypertension, and complications occurred most commonly during the mid-session period. Patients with AKI experienced complications more frequently than those with CKD, while diabetes mellitus, hypertension, lower hemoglobin, and higher blood urea and serum creatinine levels were significantly associated with their occurrence. These findings indicate that intradialytic complications are common and appear to be related to both the underlying clinical condition of the patient and the physiological stress associated with hemodialysis.

The overall frequency of intradialytic complications in the present study was 64.2%, which was comparable to the 61.5% reported by Sharma et al. among patients receiving maintenance hemodialysis. [10] Considerable variation has been reported across different settings. Meena et al. observed intradialytic complications in 98% of patients undergoing hemodialysis. [11] In contrast, Nithin et al. reported a frequency of 34.9%. [12] Jagadeesan and Vijayakumar reported an even lower frequency of 12.24%. [13] Such variation may reflect differences in patient characteristics, underlying renal disease, definitions of intradialytic complications, dialysis practices, and the intensity of monitoring. The inclusion of both CKD and AKI patients in the present study, together with the high prevalence of diabetes, hypertension, and anemia, may partly explain the relatively high frequency observed.

Among patients who developed intradialytic complications, hypotension was the most frequent event, occurring in 45.1%. This was very close to the 45.3% reported by Meena et al. [11] and the 47.4% reported by Nithin et al. [12] Ali et al. also identified hypotension as the most frequent intradialytic complication, although at a lower frequency of 28.7%. [14] Despite differences in the reported proportions, these observations consistently identify hypotension as an important clinical problem during hemodialysis.

The predominance of hypotension is physiologically plausible. During hemodialysis, ultrafiltration reduces circulating blood volume, while maintenance of blood pressure depends on adequate vascular refilling, peripheral vascular resistance, and cardiac compensation. When the rate of fluid removal exceeds the ability of these compensatory mechanisms to maintain effective circulating volume, hypotension may occur. Kanbay et al. described this imbalance between ultrafiltration and cardiovascular compensation as an important mechanism underlying intradialytic hypotension. [15] In the present population, underlying diabetes, hypertension, anemia, and acute illness may have further reduced the ability of some patients to tolerate rapid intravascular volume changes.

Davenport also emphasized the role of cardiovascular instability during hemodialysis and highlighted the contribution of fluid accumulation and aggressive fluid removal to intradialytic complications. [16] The high frequency of hypotension observed in the present study therefore supports careful assessment of volume status and adjustment of ultrafiltration according to the individual patient's clinical condition.

Muscle cramps were the second most frequent complication (21.3%), followed by hypertension (16.4%), nausea (14.8%), vomiting (13.1%), and headache (9.8%). These events may be less immediately threatening than severe hemodynamic instability. They can cause considerable discomfort, reduce tolerance to dialysis, and interfere with completion of the prescribed treatment. Alam et al. similarly reported muscle cramps, nausea, vomiting, chest pain, and other symptoms among patients receiving maintenance hemodialysis. [17] The occurrence of these symptoms together with hemodynamic disturbances suggests that changes in circulating volume, tissue perfusion, and electrolyte balance may contribute to intradialytic morbidity.

The interventions required during dialysis also reflected the predominantly hemodynamic nature of the observed complications. Reduction of ultrafiltration was the most frequently required intervention (39.3%), followed by intravenous fluids (32.8%) and medications (29.5%). Naga Sruthi et al. similarly described the use of intravenous fluids, oxygen, dextrose, and antiemetics. Other supportive measures according to the type of complication encountered during hemodialysis. [18] These findings suggest that timely recognition of complications and appropriate modification of treatment can help control many intradialytic events.

Despite the relatively high frequency of complications, dialysis was completed successfully in 74.7% of patients, while only 10.5% had interruption of dialysis. This is clinically relevant because it suggests that the occurrence of an intradialytic complication does not necessarily prevent completion of treatment when the event is identified and managed promptly. Prabhakar et al. similarly observed that most intradialytic complications could be managed successfully with timely recognition and appropriate intervention. [19] Thus, early identification and prompt management remain important components of safe hemodialysis care.

An important finding of the present study was the significantly higher frequency of intradialytic complications among patients with AKI compared with those with CKD (78.9% vs 60.5%; p=0.034). Nithin et al. also reported a greater frequency of complications among patients with AKI than among those with CKD. [12] Patients with AKI may undergo dialysis in the setting of acute metabolic abnormalities, rapidly changing volume status, systemic illness, and greater hemodynamic instability. In contrast, patients with CKD receiving repeated hemodialysis may have greater physiological and therapeutic adaptation to the procedure. Because the present analysis did not adjust for severity of illness and other potential confounding factors, AKI should be interpreted as an associated clinical factor rather than an independent predictor of intradialytic complications.

Diabetes mellitus and hypertension were also significantly associated with intradialytic complications. Complications occurred in 76.7% of patients with diabetes compared with 53.8% of those without diabetes (p=0.001). Similarly, 75.0% of patients with hypertension developed complications compared with 51.2% of those without hypertension (p<0.001). Sharma et al. also reported an association of diabetes and hypertension with intradialytic hemodynamic complications. [10] Diabetes may impair autonomic cardiovascular responses and vascular reactivity, while long-standing hypertension may be accompanied by vascular stiffness and altered volume regulation. These changes may reduce patients' ability to compensate for rapid intravascular volume shifts during dialysis.

Patients who developed intradialytic complications also had significantly higher mean blood urea (168 ± 42 vs 142 ± 36 mg/dL;

p<0.001) and serum creatinine levels (7.8 ± 2.1 vs 6.5 ± 1.8 mg/dL; p<0.001). Nithin et al. similarly reported an association between higher predialysis urea and creatinine levels and intradialytic complications. [12] Higher values may reflect greater biochemical derangement, disease severity, residual kidney function, or the timing and adequacy of dialysis rather than directly causing intradialytic complications. These biochemical parameters should therefore be interpreted primarily as markers associated with the clinical condition of the patient.

When considered together, the findings suggest that patients with acute renal dysfunction, major comorbidities, anemia, and greater biochemical abnormalities may be less able to tolerate the physiological changes that occur during hemodialysis. This supports the value of assessing clinical risk before dialysis rather than relying only on the detection of complications once the procedure has started. Dugilo et al. also demonstrated relationships between predialysis clinical parameters, dialysis settings, and intradialytic blood-pressure abnormalities. They highlighted the importance of individualised assessment during hemodialysis. [21] Patients identified as being at higher risk may therefore require closer hemodynamic monitoring and careful adjustment of fluid removal according to their clinical condition.

The findings should be interpreted in light of certain limitations. This was a single-centre study with a relatively modest sample size. This may limit the generalizability of the results. The cross-sectional observational design allows identification of associations but does not establish causal relationships. Important dialysis-related variables, including exact ultrafiltration rate, interdialytic weight gain, dialysate sodium concentration, dialysate temperature, and blood-flow rate, were not evaluated. The associations were based primarily on univariate analysis, and multivariable analysis was not performed.

CONCLUSION

Intradialytic complications were frequent among patients undergoing hemodialysis, occurring in 64.2% of the study population. Hypotension was the most frequent complication, followed by muscle cramps and hypertension. The highest proportion of complications occurred during the mid-session period. Intradialytic complications were significantly more frequent among patients with AKI than among those with CKD. Despite the frequent occurrence of intradialytic complications, dialysis was completed successfully in most patients. These findings emphasize the importance of identifying patients at higher clinical risk and maintaining close monitoring throughout hemodialysis. Particular attention should be paid to patients with AKI, diabetes, hypertension, anaemia, and greater biochemical derangement. This may facilitate early recognition and timely management of intradialytic complications.

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INFORMED CONSENT: Written informed consent was obtained from all participants before enrolment in the study.

DATA AVAILABILITY: The data supporting the findings of this study are available from the corresponding author on reasonable request, subject to institutional and ethical requirements.

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