International Journal of Life Sciences, Biotechnology and Pharma Research Vol. 14, No. 2, February 2025 Online ISSN: 2250-3137
Print ISSN: 2977-0122

DOI: 10.69605/ijlbpr_14.2.2025.147

ORIGINAL RESEARCH

Complications during dialysis in end-stage renal disease patients undergoing maintenance hemodialysis

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Received: 27 January, 2025 Accepted: 19 February, 2025 Published: 26 February, 2025

ABSTRACT

Objective: Patients with end-stage renal disease (ESRD) receiving maintenance hemodialysis are susceptible to numerous intradialytic complications, which critically affect both morbidity and mortality rates. Accurate identification of the prevalence and determinants of these complications is crucial for enhancing patient management and healthcare outcomes. **Methods:** In this observational cohort study, 104 patients undergoing maintenance hemodialysis at a tertiary healthcare facility were evaluated. Data collection focused on demographic details, existing comorbid conditions, specific dialysis-related parameters, and types of vascular access utilized. Statistical analysis, performed using SPSS, aimed to identify significant correlations between patient attributes and the occurrence of intradialytic complications. **Results:** The analysis encompassed 104 hemodialysis recipients, identifying a significant occurrence of hypotensive episodes in 59.0% of patients, accompanied by symptoms such as fatigue and muscle cramps. The predominant method of vascular access was arteriovenous fistula, used by 87.0% of patients. Adherence to the Kidney Disease Outcomes Quality Initiative (KDOQI) and the European Best Practice Guidelines (EBPG) was notably low, recorded at 11.1% and 6.8% respectively, highlighting a critical need for enhanced therapeutic and management strategies to reduce the incidence of intradialytic complications. **Conclusion:** The prevalence of intradialytic complications remains high among ESRD patients undergoing maintenance hemodialysis, with cardiovascular comorbidities playing a substantial role in increasing risk. Optimal management strategies, including meticulous fluid and medication regulation, are essential to reduce these complications and thus improve overall patient health outcomes.

Keywords: End-stage renal disease, hemodialysis, intradialytic complications, cardiovascular risk, fluid management, vascular access

INTRODUCTION

End-stage renal disease (ESRD) marks the terminal stage of chronic kidney disease (CKD), characterized by a decline in renal function to less than 15% of normal. Hemodialysis is a critical intervention in managing ESRD, facilitating essential waste removal by mechanically filtering the blood via a dialyzer. Despite its therapeutic importance, hemodialysis is fraught with potential complications that can profoundly affect patient outcomes and quality of life. These issues range from frequently observed intradialytic hypotension to rarer but serious problems such as arrhythmias and complications related to vascular access.[1,2]

Intradialytic hypotension (IDH), marked by a notable reduction in blood pressure during the dialysis session, is the most prevalent complication, affecting approximately 20-30% of dialysis treatments. This condition compromises the effectiveness of dialysis by limiting fluid removal and increases the risk of various acute and chronic health issues, including myocardial ischemia, cerebrovascular accidents, and intestinal ischemia. Furthermore, recurrent IDH episodes may lead to progressive cardiac damage, eventually manifesting as congestive heart failure, which complicates ESRD management further.[3,4]

In addition to cardiovascular concerns, hemodialysis can also cause complications related to the vascular access needed for treatment. Issues such as thrombosis, infection, and stenosis are major causes of hospitalization in hemodialysis patients, emphasizing the importance of meticulous vascular access care and surveillance.[5]

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The dialysis procedure itself also presents risks for other acute complications, including muscle cramps, arrhythmias, and air embolism. These complications necessitate immediate intervention to avoid long-term negative outcomes and underscore the need for careful adjustment of dialysis parameters and consideration of individual patient factors like underlying cardiovascular conditions, age, and concurrent medication use.[6]

With the significant morbidity associated with intradialytic complications, it is imperative to understand their predictors and develop strategies to lessen their impact. This article examines the range of intradialytic complications faced by ESRD patients on maintenance hemodialysis. By reviewing data from a cohort of 104 patients, the study evaluates the prevalence, predictors, and outcomes of these complications and offers insights into effective prevention and management tactics. This research contributes to the overarching objective of enhancing patient safety and improving therapeutic results for a demographic that is expanding in line with the global rise in chronic kidney disease incidence.

MATERIALS AND METHODS

Study Design and Participants: This observational cohort study was carried out at a tertiary care facility, enrolling 104 end-stage renal disease (ESRD) patients undergoing regular maintenance hemodialysis. Recruitment occurred from January to December 2021. Eligible participants were adults aged 18 years and above, diagnosed with ESRD and having undergone hemodialysis consistently for at least three months before the study commenced. Exclusion criteria encompassed individuals with acute renal failure, those receiving peritoneal dialysis, and patients with a non-renal related life expectancy of less than six months.

Data Collection: Initial demographic and clinical information was gathered upon enrollment, covering variables such as age, gender, and comorbidities including hypertension, diabetes, heart failure, and HIV status. Details on vascular access type and antihypertensive medication usage were also noted. Specific dialysis-related metrics recorded included pre- and post-dialysis weights, dry weight, interdialytic intervals, interdialytic weight gain (IDWG), ultrafiltration rates, and total ultrafiltration volumes from the dialysis session logs.

Dialysis Procedure: Patients underwent hemodialysis sessions lasting 3 to 4 hours, typically two to three times weekly, utilizing standard bicarbonate dialysis solutions through polysulfone membranes. The temperature of the dialysate was consistently maintained at 36.5°C. Dry weights were determined by the attending nephrologist, based on clinical evaluations and patient-reported symptoms.

Statistical Analysis: Continuous data were reported as means ± standard deviation (SD) or medians and interquartile ranges (IQR) based on data distribution. Categorical variables were summarized using frequencies and percentages. Data normality was assessed via the Shapiro-Wilk test. Continuous variables were compared between groups using either the Student's t-test or the Mann-Whitney U test depending on data distribution. Chi-square or Fisher's exact tests were utilized for categorical data analyses, applying the latter when expected frequencies were below five. Statistical significance was set at a p-value less than 0.05. All statistical procedures were conducted using SPSS version 26.0 (IBM Corp., Armonk, NY, USA).

RESULTS

The demographic and clinical profile of the study population comprised 104 patients on maintenance hemodialysis, with a significant majority being male (67.3%, n=70) compared to females (32.7%, n=34). The mean age of the participants was 51.2 years, demonstrating a substantial variance (SD=14.8 years). Notably, the prevalence of comorbid conditions was high, with hypertension being the most common (94.2%), followed by diabetes (29.8%), heart failure (11.5%), and HIV infection (6.7%). Among hypertensive individuals, the median duration of hypertension was 6.5 years, with a majority (82.7%) receiving antihypertensive therapy predominantly comprising calcium channel blockers (70.4%) and ACE inhibitors or ARBs (50.0%).

The vascular access for hemodialysis predominantly involved arteriovenous fistulas, utilized by 87.0% of the patients, while central venous catheters were used by 13.0%. The regimen of dialysis was primarily biweekly (94.2%), with patients having a median dialysis duration of 31 months. The typical interdialytic interval was two days, and the average ultrafiltration metrics included a rate of 810 mL/h and a volume of 3200 mL per session.

Significant hypotensive episodes, indicated by a decrease in systolic blood pressure of ≥20 mmHg or mean arterial pressure by ≥10 mmHg, occurred in 59.0% of dialysis sessions. Other clinical symptoms reported included tiredness (5.8%), muscle cramps (4.9%), lightheadedness (3.9%), headaches (2.4%), nausea (1.0%), and vomiting (0.9%). Management strategies for these complications ranged from the Trendelenburg position (5.3%) to isotonic saline administration (3.4%), alongside adjustments in dialysate sodium concentration and ultrafiltration rates.

Adherence to dialysis guidelines was modest, with 11.1% of sessions meeting the Kidney Disease Outcomes Quality Initiative (KDOQI) standards and 6.8% adhering to the European Best Practice Guidelines (EBPG) for Hemodynamic Instability.

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Figure 1: Distribution of Baseline Characteristics Among the Study Population depicts the proportional representation of demographic and clinical characteristics in the cohort, illustrating the prevalence of comorbidities alongside gender distribution.

Table 1: Baseline Characteristics of the Population provides detailed statistical data on demographic and clinical profiles, including specific comorbidities and vascular access types.

Figure 2: Dialysis Parameter Metrics and Variability Across Sessions visualizes the dialysis parameters, showing variability in measurements such as interdialytic intervals, weights, and ultrafiltration rates, which are critical in assessing and managing the risk of intradialytic complications.

Table 2: Dialysis Parameters lists the specific dialysis parameters, providing quantifiable metrics essential for evaluating the efficacy and safety of the dialysis sessions.

Figure 3: Incidence of Hypotensive Events, Clinical Symptoms, and Therapeutic Interventions During Dialysis Sessions graphically represents the frequency of hypotensive events and associated clinical symptoms, as well as the interventions employed to manage these complications, highlighting the challenges faced during dialysis sessions and the importance of tailored therapeutic strategies.

Table 3: Incidence of Hypotension, Clinical Symptoms, and Therapeutic Measures During Dialysis Sessions offers a detailed account of the percentage of dialysis sessions affected by specific hypotensive and other clinical events, including the types of nursing interventions implemented to address these occurrences, and guideline adherence rates, underscoring the clinical complexity and the critical need for protocol adherence to improve patient outcomes.

TABLE 1: BASELINE CHARACTERISTICS OF THE POPULATION

Characteristics	n (%)
Gender	
Female	34 (32.7)
Male	70 (67.3)
Age (years)	**mean±SD**
	51.2±14.8
Comorbidities	
Hypertension	98 (94.2)
Diabetes	31 (29.8)
Heart failure	12 (11.5)
HIV infection	7 (6.7)
Hypertension (n=98)	
Duration (years), median (IQR)	6.5 (3–14)
Use of antihypertensive drugs	81 (82.7)
Class of antihypertensive drugs	
Calcium channel blockers	69 (70.4)
ACEI/ARB	49 (50.0)
Central-acting agents	17 (17.3)
Beta-blockers	16 (16.3)
Vascular access	
Arteriovenous fistulae	101 (87.0)
Central venous catheter	3 (13.0)
Number of dialysis/week	
2	98 (94.2)
3	6 (5.8)
Duration on dialysis (month) Median (IQR)	31 (11–60)

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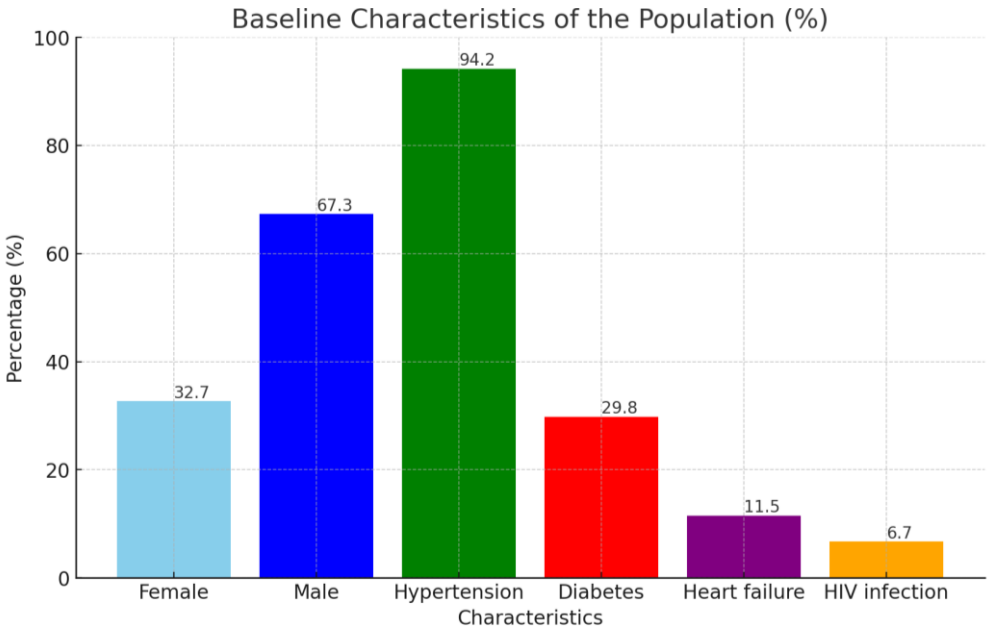

FIGURE 1: DISTRIBUTION OF BASELINE CHARACTERISTICS AMONG THE STUDY POPULATION

TABLE 2: DIALYSIS PARAMETERS

Parameters	Value (mean±SD or median (IQR))
Interdialytic interval (days)	2 (1–3)
Dry weight (kg)	69.2±13.2
Weight before dialysis (kg)	72.8±13.6
Weight after dialysis (kg)	69.9±13.5
IDWG (kg)	2.9±1.4
Ultrafiltration rate (mL/h)	810±250
Ultrafiltration rate (mL/kg/h)	11.1±3.8
Ultrafiltration rate > 1000 mL/h, n (%)	11 (1.1)
Ultrafiltration volume (mL)	3200±1015

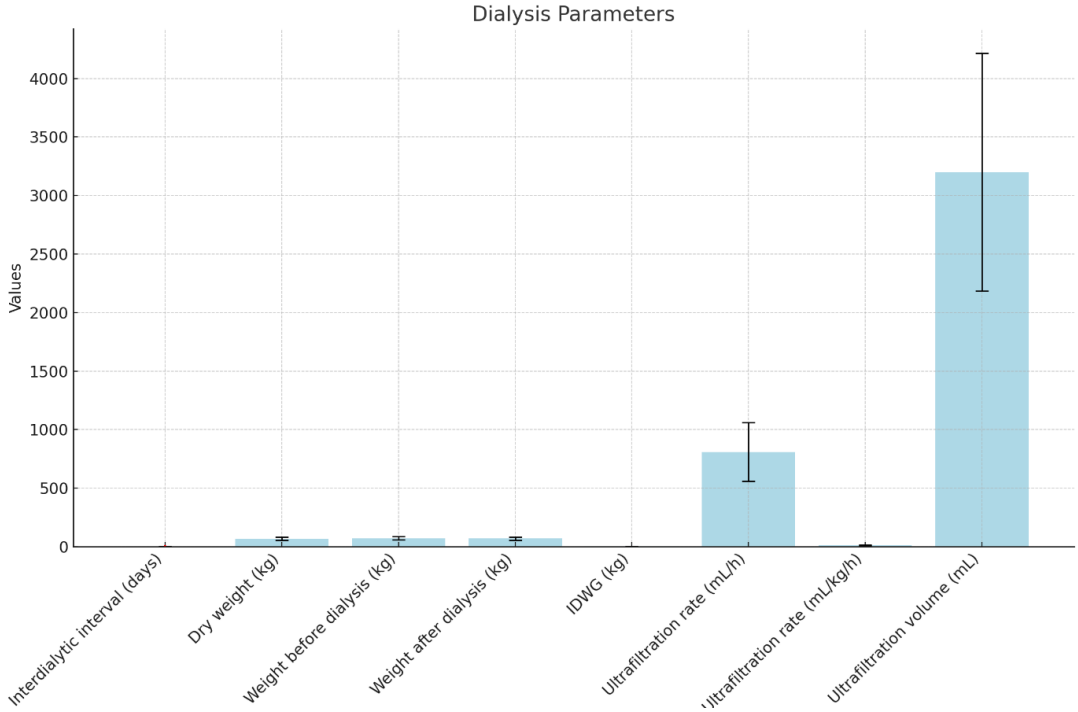

FIGURE 2: DIALYSIS PARAMETER METRICS AND VARIABILITY ACROSS SESSIONS

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TABLE 3: INCIDENCE OF HYPOTENSION, CLINICAL SYMPTOMS, AND THERAPEUTIC MEASURES DURING DIALYSIS SESSIONS

Category	Incident (Percentage of Dialysis Sessions)
Reduction in Blood Pressure	
SBP ≥20 mmHg or MAP ≥10 mm Hg	612 (59.0%)
Clinical Manifestations	
Any Manifestation	149 (14.4%)
Tiredness	60 (5.8%)
Muscle Cramps	51 (4.9%)
Lightheadedness	40 (3.9%)
Head Pain	25 (2.4%)
Sickness	10 (1.0%)
Emesis	9 (0.9%)
Nursing Interventions	
Any Intervention	140 (13.5%)
Trendelenburg Position	55 (5.3%)
Isotonic Saline Administration	35 (3.4%)
Increased Dialysate Sodium	20 (1.9%)
Ultrafiltration Reduction/Stop	28 (2.7%)
Dialysis Session Interruption	15 (1.4%)
Guideline Adherence	
KDOQI Standards	115 (11.1%)
Full EBPG Standards	70 (6.8%)

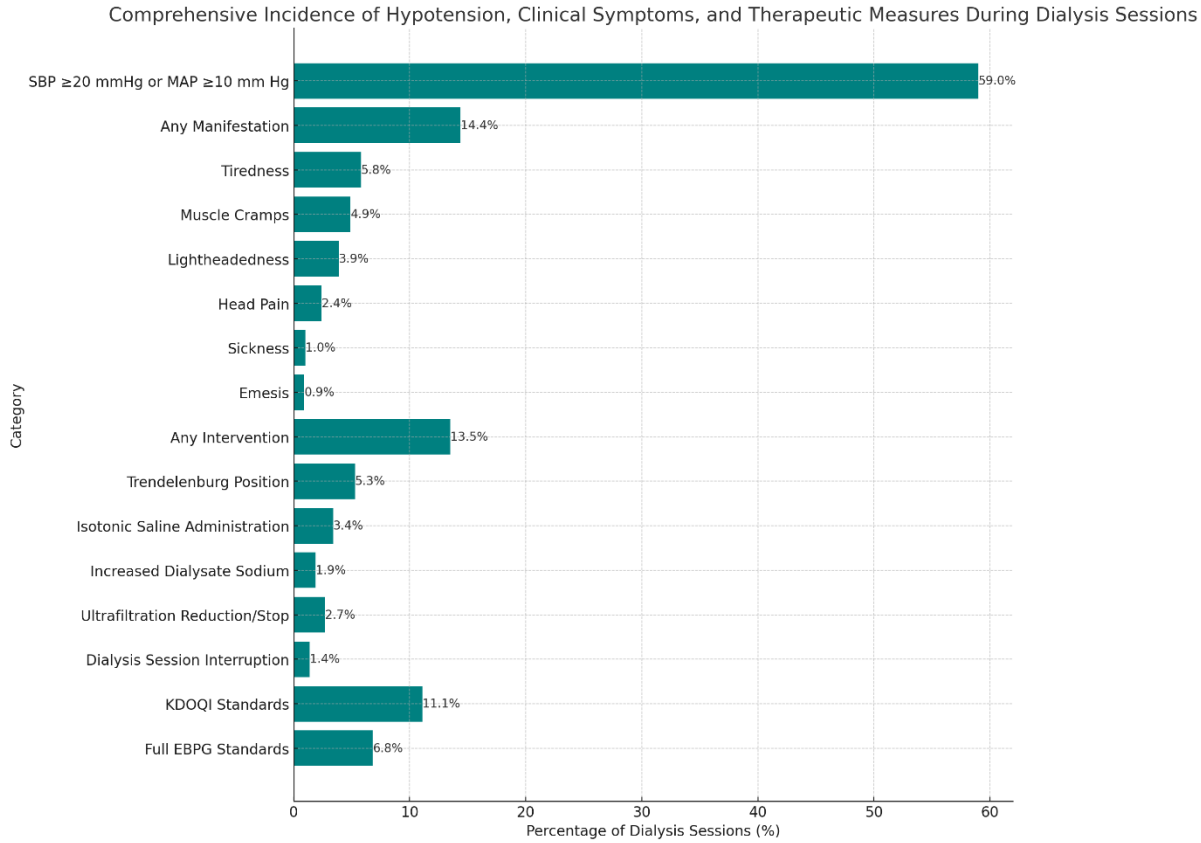

FIGURE 3: INCIDENCE OF HYPOTENSIVE EVENTS, CLINICAL SYMPTOMS, AND THERAPEUTIC INTERVENTIONS DURING DIALYSIS SESSIONS

DISCUSSION

This investigation delves into the complexities of intradialytic complications in individuals with end-stage renal disease (ESRD) receiving maintenance hemodialysis, illuminating significant issues such as hypotension, challenges with vascular access, and the impact of comorbid conditions. The analysis reveals a substantial prevalence of hypertension (94.2%) and diabetes (29.8%), highlighting the widespread cardiovascular burden within this demographic. These

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comorbidities not only heighten the risk of dialytic complications but also intensify the overall management difficulties of ESRD.[7,8]

Intradialytic hypotension (IDH), evident through indicators like interdialytic weight gain and ultrafiltration rates, poses a severe risk, potentially leading to critical consequences such as myocardial and cerebral ischemia. The prevalent occurrence of IDH may be partially ascribed to the aggressive fluid removal and the commonality of cardiac inadequacies within this patient group. This observation aligns with previous research linking rapid fluid extraction to heightened mortality and cardiovascular incident rates.[9]

Concerning vascular access, complications were relatively rare, with a predominant use of arteriovenous fistulas (97.1%), recognized for their lower risk profile compared to central venous catheters. However, the existence of a minor proportion of patients employing central venous catheters (2.9%) underscores the necessity for rigorous monitoring and proactive management to avert severe complications such as infections and thrombosis.[10]

The patterns of antihypertensive medication usage, particularly the prevalent reliance on calcium channel blockers and central-acting agents, reflect an effort to regulate blood pressure fluctuations and manage cardiovascular jeopardy inherent in ESRD. This therapeutic approach is in accord with current guidelines that advocate the use of renin-angiotensin-aldosterone system inhibitors to diminish cardiovascular peril in patients undergoing dialysis.[11,12]

Additionally, data concerning dialysis metrics like ultrafiltration rate and interdialytic intervals underscore the critical need for meticulous fluid management to prevent both dehydration and fluid overload, which could precipitate intradialytic complications. Our results indicate that fine-tuning these parameters could diminish the frequency of IDH and enhance clinical outcomes, supported by literature that advocates for individualized dialysis regimens tailored to patient-specific needs.

CONCLUSION

In conclusion, this research elucidates the intricate relationship between comorbid conditions, dialysis variables, and intradialytic complications in individuals afflicted with end-stage renal disease (ESRD). It underscores the imperative for tailored care approaches that adapt to the unique risks each patient faces and the fluid nature of dialysis treatments. By prioritizing preventative strategies and refining dialysis protocols, there is potential to elevate patient safety and ameliorate outcomes for those dependent on hemodialysis.

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