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Intradialytic Hypertension and Its Impact on Hospitalization and Mortality in Patients with End Stage Renal Disease.

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Abstract

Background: In patients with end-stage renal disease receiving continuous haemodialysis, IDH (Intradialytic Hypertension), a counterintuitive increase in blood pressure during or right after haemodialysis, is a growing yet underdiagnosed problem. It is associated with adverse cardiovascular outcomes and increased healthcare utilization, yet its impact on hospitalization and mortality in Indian patients remains inadequately characterized. The purpose of this study was to assess the prevalence of IDH in ESRD patients receiving regular haemodialysis as well as its correlation with hospitalisation and mortality. ***Methods:*** A prospective, observational study was conducted in the Department of General Medicine, Tagore Medical College and Hospital, Chennai, over a 12-month period (January–December 2024). A total of 155 adult ESRD patients on thrice-weekly maintenance hemodialysis for at least three months were enrolled. Blood pressure was monitored pre-dialysis, every 30 minutes during dialysis, and post-dialysis across three consecutive sessions. IDH was defined as either a rise in SBP (Systolic Blood Pressure) ≥10 mmHg from pre- to post-dialysis, or a ≥10 mmHg rise two hours into dialysis, occurring across three consecutive sessions. Patients were followed for 12 months to assess hospitalization and all-cause mortality, and data were analyzed statistically, with $p<0.05$ considered significant. ***Results:*** IDH was significantly associated with both hospitalization ($p=0.011$) and mortality ($p=0.045$). On logistic regression adjusted for comorbid diabetes and hypertension, IDH independently increased the odds of hospitalization by 2.76 times (95% CI: 1.35–5.64) and mortality by 2.48 times (95% CI: 1.01–6.09). The IDH group showed a mean post-dialysis SBP increase of +18.9 mmHg, in contrast to a reduction observed in the non-IDH group. ***Conclusion:*** IDH is a prevalent and clinically significant condition that independently predicts poor outcomes - including higher rates of hospitalization and mortality - in hemodialysis patients. Early identification through routine intradialytic BP monitoring and targeted management strategies are critical to reducing morbidity, mortality, and healthcare burden in this high-risk population.

Keywords: Intradialytic Hypertension; End Stage Renal Disease, Hemodialysis, Blood Pressure, Hospitalization, Mortality, Dialysis Complications.

INTRODUCTION

A significant global public health concern, CKD (Chronic Kidney Disease) affects 8–16% of the world's population and significantly increases morbidity and mortality.[1] Patients need renal replacement therapy when CKD advances to ESRD (End-Stage Renal Disease), with continuous haemodialysis being the most popular treatment option. Although hemodialysis is lifesaving, it is associated with several acute and chronic complications that significantly affect patient outcomes, quality of life, and healthcare utilization.[2]

Among these complications, IDH (Intradialytic Hypertension) has emerged as an important yet often underrecognized clinical problem. IDH is characterised by a paradoxical rise in blood pressure during or right after a dialysis session, in contrast to the anticipated drop in blood pressure brought on by ultrafiltration and fluid elimination during dialysis. It is typically described as an increase in SBP (Systolic Blood Pressure) of at least 10 mmHg between measurements taken before and after dialysis when there are no other known causes.[3] This unexpected rise in blood pressure complicates dialysis management, particularly among patients with pre-existing cardiovascular disease.

The reported prevalence of IDH ranges from 10% to 40%, with variations attributable to differences in study populations and diagnostic criteria.[4,5] Despite its relatively high prevalence, IDH remains inadequately recognized and managed in routine clinical practice. The condition has a multifactorial pathophysiology involving sodium imbalance due to high dialysate sodium concentrations, endothelial dysfunction, increased sympathetic nervous system activity, and persistent volume overload.[6,9,10]. Additional contributing factors include poor adherence to antihypertensive medications, autonomic dysfunction, and excessive interdialytic weight gain, all of which increase the complexity of its management.

Recurrent episodes of IDH are linked to poor cardiovascular outcomes, such as left ventricular hypertrophy, heart failure, cerebrovascular events, and higher all-cause mortality, according to mounting data.[7,8] Furthermore, the increased risk of hospitalization due to cardiovascular complications and fluid overload places a considerable economic burden on both patients and healthcare systems.[11] Therefore, understanding the prevalence and associated risk factors of IDH is essential for improving clinical management, optimizing dialysis care, and reducing adverse outcomes among patients undergoing maintenance hemodialysis.

Aims and Objectives

The purpose of this study was to assess the incidence and clinical consequences of IDH in patients receiving continuous haemodialysis three times a week for ESRD. The primary objective was to determine the prevalence of IDH in this patient population. The secondary objectives were to assess the association between IDH and common comorbid conditions, particularly diabetes mellitus and hypertension, evaluate the impact of IDH on patient morbidity, and determine its association with all-cause mortality during a 12-month follow-up period.

MATERIALS AND METHODS

Study Design

This study was designed as a prospective observational analytical study conducted in the Department of General Medicine, Tagore Medical College and Hospital, Chennai. The study was carried out over a 12-month period, from January 2024 to December 2024.

Inclusion and Exclusion Criteria

The study included adult patients aged 18 years and above with ESRD who had been undergoing maintenance hemodialysis three times per week for at least three months and had no vascular, infectious, or bleeding complications at the time of enrollment. Patients were excluded if they had missed two or more hemodialysis sessions in the preceding month, had cardiac arrhythmias, morbid obesity (BMI ≥40 kg/m²), uncontrolled diabetes mellitus, autonomic dysfunction, or were receiving alternative renal replacement therapies, such as peritoneal dialysis.

Sample Size Calculation

A total of 155 patients were included based on the sample size calculation derived from the prevalence rate of intradialytic hypertension in existing literature.

Data Collection Procedure

This study followed a structured data collection protocol. At baseline, all eligible participants underwent a comprehensive clinical assessment, including measurement of blood pressure and evaluation of demographic and clinical characteristics. Blood pressure targets were defined according to the JNC VIII guidelines, with target values of <140/90 mmHg for patients younger than 60 years and <150/90 mmHg for those aged 60 years and above.

Baseline investigations included CBC (Complete Blood Count), RFT (Renal Function Tests), serum electrolytes, ECG (Electrocardiogram), ECHO (Echocardiography), and ultrasonography (USG) of the abdomen and pelvis. Dialysis-related parameters such as interdialytic weight gain, pre- and post-dialysis body weight, and ultrafiltration volume were also recorded.

Intradialytic blood pressure monitoring was performed by measuring blood pressure before dialysis following a 5-minute rest in the supine position, at 30-minute intervals during hemodialysis, and 5 minutes after completion of the session. This monitoring protocol was repeated over three consecutive hemodialysis sessions.

IDH was defined as either an increase in SBP of ≥10 mmHg from pre- to post-dialysis across three consecutive sessions or an increase in SBP of ≥10 mmHg occurring two hours into dialysis after ultrafiltration and consistently observed across three sessions.

Based on the presence or absence of IDH, participants were categorized into two groups: Group 1 (patients without IDH) and Group 2 (patients with IDH). All patients were subsequently followed for a period of 12 months, during which the

primary outcomes assessed were morbidity, defined as non-access and non-transplant-related hospitalizations, and all-cause mortality.

Statistical Analysis

The Statistical Package for the Social Sciences (SPSS) version 25.0 was used to analyse the data after it was imported into Microsoft Excel. Baseline characteristics were summarised using descriptive statistics including mean, standard deviation, and frequency distributions. The relationships between IDH and hospitalization/mortality outcomes were investigated using inferential analysis, which included the chi-square test and logistic regression. Statistical significance was defined as a p-value of less than 0.05.

RESULTS

Table 1. Demographic Characteristics of Study Participants (n=155)

Variable	Frequency (n)	Percentage (%)
Age Group (in years)		
20–34	28	18.1
35–49	45	29.0
50–64	52	33.5
65–79	25	16.1
≥80	5	3.2
Gender		
Male	85	54.8
Female	70	45.2

The study population's demographic profile is shown in Table 1. The age group of 50–64 years old made up the majority of participants (33.5%), followed by the age group of 35–49 years old (29.0%). Males constituted a slightly higher proportion (54.8%) than females (45.2%), indicating a male predominance among ESRD patients undergoing maintenance hemodialysis.

Table 2. Prevalence of Intradialytic Hypertension and Gender-Wise Distribution

Variable	IDH Present (%)	IDH Absent (%)
Male	44.2	54.8
Female	55.8	45.2
IDH Status	**Frequency**	**Percentage (%)**
Yes	72	46.5
No	83	53.5

Table 2 demonstrates the prevalence of IDH among the study participants. IDH was observed in 46.5% of patients, while 53.5% did not exhibit IDH. Female patients showed a relatively higher proportion of IDH compared with males.

Table 3. Primary Renal Disease in Patients with and without IDH

Primary Renal Disease	With IDH (n=72)	Without IDH (n=83)	p-value
Diabetic Nephropathy	29 (40.3%)	40 (48.2%)	
Hypertensive Nephrosclerosis	20 (27.8%)	32 (38.6%)	
Chronic Glomerulonephritis	17 (23.6%)	9 (10.8%)	
Others	6 (8.3%)	2 (2.4%)	0.582

Table 3 observes the distribution of primary renal diseases among patients with and without IDH. Diabetic nephropathy was the most common etiology in both groups. Although chronic glomerulonephritis appeared more frequent among patients with IDH, the overall distribution of renal disease etiologies was not statistically significant (p=0.582).

Table 4. Association of Comorbidities with Intradialytic Hypertension

Comorbidity	With IDH (n=72)	Without IDH (n=83)	p-value
Diabetes Mellitus	51 (70.8%)	44 (53.0%)	<0.05
Hypertension	60 (83.3%)	53 (63.9%)	<0.05
Coronary Artery Disease	18 (25.0%)	19 (22.9%)	0.762

Table 4 illustrates the association between comorbid conditions and IDH. Diabetes mellitus and hypertension were significantly more prevalent among patients with IDH ($p<0.05$), whereas the prevalence of coronary artery disease was comparable between the groups and showed no significant association.

Table 5. Comparison of Hemodynamic Parameters between Patients with and without IDH

Parameter	With IDH	Without IDH	p-value
Change in SBP (Post–Pre)	15.7 ± 5.0	-4.2 ± 10.7	<0.05
Pre-HD SBP (mmHg)	149.4 ± 18.1	150.6 ± 23.2	0.810
Pre-HD DBP (mmHg)	68.9 ± 13.9	69.9 ± 13.0*	0.542
Post-HD SBP (mmHg)	164.8 ± 18.6	149.1 ± 19.7	<0.05
Post-HD DBP (mmHg)	75.8 ± 13.1	72.0 ± 13.0	0.122
Pre-HD MAP (mmHg)	96.3 ± 12.6	99.6 ± 14.9	0.234
Post-HD MAP (mmHg)	107.1 ± 11.9	98.3 ± 13.6	<0.05
Dialysis Weight Gain (L)	2.4 ± 0.71	2.5 ± 0.82	0.491

Table 5 compares blood pressure parameters between the two groups. Patients with IDH demonstrated a significant rise in systolic blood pressure and post-dialysis mean arterial pressure compared with those without IDH. No significant differences were observed in pre-dialysis blood pressure measurements or interdialytic weight gain.

Table 6. Antihypertensive Medications and Laboratory Parameters

Variable	With IDH	Without IDH	p-value
ACE Inhibitors	5 (6.9%)	5 (6.0%)	0.121
ARBs	31 (43.1%)	42 (50.6%)	0.505
Alpha Blockers	0 (0%)	5 (6.0%)	0.244
Beta Blockers	30 (41.7%)	36 (43.4%)	0.815
Calcium Channel Blockers	63 (87.5%)	49 (59.0%)	0.035
Nitrates	10 (13.9%)	18 (21.7%)	0.103
Number of Antihypertensives	2.1 ± 1.0	2.0 ± 1.2	0.439
Hemoglobin (g/dL)	11.0 ± 1.6	10.9 ± 1.5	0.648
Albumin (g/dL)	3.7 ± 0.60	3.8 ± 0.57	0.842
Creatinine (mg/dL)	8.4 ± 2.3	8.9 ± 2.7	0.741
Corrected Calcium (mg/dL)	8.9 ± 1.5	9.0 ± 1.6	0.332
Phosphorus (mg/dL)	5.6 ± 1.9	5.7 ± 2.1	0.089

Table 6 summarizes antihypertensive medication use and laboratory parameters. Calcium channel blocker use was significantly higher among patients with IDH ($p=0.035$). No significant differences were observed in other medication classes or laboratory variables between the groups.

Table 7. Morbidity, Mortality and Logistic Regression Analysis

Outcome	With IDH (n=72)	Without IDH (n=83)	p-value
Hospitalization	31 (43.1%)	18 (21.7%)	<0.05
Mortality	10 (13.8%)	5 (6.0%)	<0.05
Variable	**Odds Ratio**	**95% CI**	**p-value**
Hospitalization Model			
IDH (Yes vs No)	2.76	1.35–5.64	0.004
Diabetes	1.53	0.78–3.01	0.216
Hypertension	1.68	0.89–3.14	0.105
Mortality Model			
IDH (Yes vs No)	2.48	1.01–6.09	0.047
Diabetes	1.92	0.82–4.51	0.129
Hypertension	2.01	0.87–4.63	0.095

Table 7 illustrates the impact of IDH on clinical outcomes. Patients with IDH experienced significantly higher rates of hospitalization and mortality over the 12-month follow-up period. Logistic regression analysis further demonstrated that IDH independently increased the odds of hospitalization by 2.76 times and mortality by 2.48 times, confirming its role as an important prognostic marker in ESRD patients undergoing maintenance hemodialysis.

DISCUSSION

Prevalence of Intradialytic Hypertension

In the present study, the prevalence of intradialytic hypertension (IDH) was 45.5%, which is comparable to previously reported prevalence rates ranging from 10% to 40% in the literature.[4,5] A similar prevalence of 43% was reported by Kale et al.[4] However, substantially lower prevalence rates have been documented in several large-scale studies. The CLIMB study, which defined IDH as an average systolic blood pressure (SBP) increase of ≥10 mmHg across four dialysis sessions, reported a prevalence of 13.2%.[12] Dorhout Mees [13] documented prevalence rates ranging from 5% to 15%, while data from the USRDS (United States Renal Data System) demonstrated a prevalence of 12.2%.[7] Variations in prevalence across studies may be attributed to differences in patient populations, definitions of IDH, dialysis practices, and methods of blood pressure assessment.

Comorbidities

The present study demonstrated that patients with IDH had a higher burden of comorbid conditions, particularly diabetes mellitus and hypertension, which were present in 52.3% and 56.1% of patients, respectively. These comorbidities are well-recognized contributors to intradialytic blood pressure variability and adverse cardiovascular outcomes.[14] Although logistic regression analysis revealed an increased risk of hospitalization and mortality among patients with diabetes and hypertension, these associations did not achieve statistical significance. Similar findings have been reported by Van Buren et al.[15] and Inrig et al.[2] who observed a higher cardiovascular risk profile among patients with IDH.

Several physiological studies further support the association between comorbid conditions and IDH. Fishbane et al.[16] compared 21 hemodialysis patients and found that individuals with minimal changes in mean arterial pressure (ΔMAP ≈ 1 mmHg) following dialysis had significantly higher levels of atrial natriuretic peptide (ANP) than patients whose MAP decreased by approximately 20 mmHg. Furthermore, reduction of dry weight in three patients reversed the hypertensive response and lowered ANP levels. Similarly, another study[17] involving patients with intradialytic blood pressure rises and cardiac dilatation demonstrated that intensive ultrafiltration over time normalized both blood pressure patterns and cardiac dimensions. Hasselblad et al.[18] reported that patients whose MAP increased by 6% during dialysis had significantly higher pulse wave velocity compared with those whose MAP decreased by 17%. Increased pulse wave velocity is a known predictor of death in individuals with ESRD, making this observation clinically significant.[19,20]

Hospitalization

The present study identified a significant association between IDH and hospitalization risk. Multivariate logistic regression analysis revealed that patients with IDH had a 2.75-fold higher odds of hospitalization (95% CI: 1.35–5.64; p = 0.011) compared with those without IDH. These findings are consistent with previous reports. Inrig et al.[21] demonstrated a 2.5-fold increased risk of hospitalization among patients with persistent IDH, while the CLIMB study similarly reported an elevated risk of the combined outcome of hospitalization and mortality among patients who experienced post-dialysis systolic blood pressure elevations[12]

The increased hospitalization risk associated with IDH may be attributable to recurrent cardiovascular symptoms such as chest discomfort, dizziness, episodes of fluid overload, and the subsequent need for inpatient management and diagnostic evaluation. These findings emphasize the importance of identifying and managing IDH as a modifiable risk factor in hemodialysis patients.

Mortality

In the present study, IDH was significantly associated with increased all-cause mortality, with an adjusted odds ratio of 2.48 (95% CI: 1.01–6.09; p = 0.045). This observation is in agreement with previous studies demonstrating an association between post-dialysis systolic blood pressure elevation and adverse survival outcomes.

Li et al.[22] in a meta-analysis, reported a significant association between IDH and 12-month mortality. Similarly, Yang et al.[23] found that a post-dialysis SBP increase greater than 5 mmHg was associated with a 3.9-fold increase in mortality risk. Data from the USRDS indicated that every 10 mmHg increase in SBP was associated with a 12% increase in mortality over a two-year period[7] Inrig et al.[24] also reported a modest increase in mortality among patients with IDH (HR 1.12). Additional evidence further supports these findings. Inrig et al.[6] observed a 6% increase in two-year all-cause mortality among patients with a ΔSBP greater than 5 mmHg. Losito et al. [25] reported increased cardiovascular mortality over a follow-up period of 26.8 months among patients with a ΔSBP exceeding 10 mmHg. Park et al.[26] in a cohort of 113,255 patients, demonstrated that increasing ΔSBP was associated with higher all-cause and cardiovascular mortality over a mean follow-up of 2.2 years.

Nonetheless, some research has revealed more intricate connections between mortality and blood pressure. In a study of 16,959 incident haemodialysis patients, Hasselblad et al. [26] discovered that lower post-dialysis SBP (<110 mmHg) was

linked to higher mortality, while higher pre-dialysis SBP (>160 mmHg) was linked to decreased mortality. However, the study did not model SBP before and after dialysis at the same time. After controlling for comorbidities and interdialytic weight gain, Foley et al.'s analysis of data from 11,142 USRDS patients revealed no significant correlation between pre- or post-hemodialysis SBP and all-cause death.[27] Wide pulse pressure, however, was found to be an independent predictor of long-term mortality. [27]

Short-term outcome data are limited but increasingly available. Inrig et al.[2] reported that patients with ΔSBP ≥10 mmHg had twice the odds of hospitalization or death within six months. In another study, Inrig et al. [7] observed a 2.17-fold increase in adjusted odds of non-access-related hospitalization or death over six months among patients with post-dialysis SBP elevations, although the hazard ratio did not reach statistical significance (HR 0.98, p = 0.271). Park et al.[26] in a secondary analysis of 1,748 patients, found that each 1 mmHg increase in post-dialysis SBP was associated with a 2% increase in the odds of non-access-related hospitalization or death. Additionally, a retrospective analysis involving 113,255 patients demonstrated a U-shaped relationship between SBP change and mortality, with increased risk observed both among patients experiencing post-dialysis SBP rises greater than 5 mmHg and among those with marked SBP reductions of approximately 45 mmHg.

Hemodynamic Trends in Intradialytic Hypertension

In the present study, patients with IDH exhibited a mean post-dialysis systolic blood pressure increase of +18.9 mmHg, in contrast to the expected reduction in SBP observed among patients without IDH following ultrafiltration. This abnormal hypertensive response supports several proposed pathophysiological mechanisms underlying IDH. These include sodium imbalance, particularly in relation to elevated dialysate sodium concentrations,[17] enhanced sympathetic nervous system activity,[21] and impaired endothelial function. Collectively, these factors contribute to abnormal vascular regulation during and after dialysis, resulting in paradoxical elevations in blood pressure despite fluid removal. Developing focused therapeutic approaches to lessen the cardiovascular load linked to IDH requires an understanding of these pathways.

Limitations

This study has several limitations. The relatively small sample size and the predominance of patients with a dialysis vintage of less than one year may have limited the ability to detect significant associations, particularly with mortality. Blood pressure measurements were based on routine pre- and post-dialysis recordings rather than ambulatory or intradialytic monitoring, which may not fully reflect the true hemodynamic burden. In addition, the lower prevalence of high-risk clinical features and the possibility of residual confounding from unmeasured factors, such as medication adherence, inflammatory status, and volume shifts, may have influenced the observed associations.

CONCLUSION

Among patients receiving maintenance haemodialysis, intradialytic hypertension is a frequent and clinically significant complication that may have a negative impact on hospitalisation and mortality. Early identification and individualized management through appropriate fluid control, optimized antihypertensive therapy, and regular blood pressure monitoring are essential. Patients with end-stage renal illness receiving dialysis may benefit from improved clinical outcomes and higher-quality treatment if standardised screening and management procedures are put into place.

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