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EFFICACY OF INTRADIALYTIC HYPOTENSION AMONG END STAGE RENAL DISEASE PATIENTS UNDERGOING CONVENTIONAL MAINTAINANCE HEMODIALYSIS

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Abstract

Background: Intradialytic hypotension remains one of the most frequent complications during hemodialysis, affecting somewhere between 5% to 40% of patients depending on the population and definition used. It happens when blood pressure drops sharply during treatment, which can lead to things like organ damage, longer hospital stays, and even higher mortality rates.

Objective: This study aimed to figure out whether certain patient characteristics and dialysis parameters could predict intradialytic hypotension in people with end stage renal disease who were getting regular maintenance hemodialysis. More specifically, we wanted to see if things like age, gender, body mass index, how long someone had been on dialysis, and some treatment settings had any real connection to IDH episodes.

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Methods: We did a cross sectional study at Muhammad Sulman Khalid Hospital in Lahore, looking at 70 adult patients who had been on conventional maintenance hemodialysis for at least three months. Data collection took about four months.The gathered information on demographics, comorbidities, dialysis parameters, and clinical factors. Blood pressure was monitored during sessions to identify IDH episodes. For analysis we used SPSS 27, running chi-square tests, one way ANOVA, and ROC curve analysis to see what actually predicted IDH.

Results: The average age of our patients was 51.66 years and their mean BMI was pretty low at 18.54. Most had been on dialysis for around 2.22 years. Interestingly, IDH was a bit more common in males at 68.6% compared to 60% in females, but that difference wasn't statistically significant ($p = .454$). None of the individual factors we looked at really stood out on their own. Age had an AUC of .687 ($p = .036$) which was significant but not amazing, while BMI (.536, $p = .892$), blood flow rate (.621, $p = .172$), and dialysis duration (.456, $p = .624$) all failed to reach significance. However when we put everything together into a combined model, the ROC curve gave us an AUC of 0.856 ($p < .001$), which is actually pretty good.

Conclusion: No single clinical factor reliably predicted intradialytic hypotension by itself, but the combination of variables did a decent job at identifying at risk patients. Age showed some promise as a predictor, but honestly we need more research with larger samples to really nail down what works best.

INTRODUCTION

Chronic kidney disease (CKD) has emerged as a major global public health challenge, with its prevalence increasing dramatically over the past three decades. In 2023, approximately 788 million adults worldwide were living with CKD compared with 378 million in 1990, and the disease ranked as the ninth leading cause of death globally, accounting for nearly 1.48 million deaths (1). The progression of CKD eventually leads to end-stage renal disease (ESRD), also known as kidney failure with replacement therapy (KFRT), where renal function becomes irreversible and renal replacement

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therapy is required for survival. Global KFRT cases reached approximately 4.59 million in 2023, with low- and middle-income countries such as Pakistan facing particularly severe challenges because of limited healthcare resources, inadequate dialysis access, and increasing rates of diabetes and hypertension (2).

Hemodialysis remains the most widely used renal replacement therapy for ESRD patients and functions by removing excess fluid, toxins, and electrolytes through an artificial dialyzer. Although lifesaving, maintenance hemodialysis exposes patients to repeated episodes of circulatory stress and several acute complications, among which intradialytic hypotension (IDH) is the most common and clinically significant complication (3). The Kidney Disease Outcomes Quality Initiative (KDOQI) defines IDH as a fall in systolic blood pressure of ≥20 mmHg or a decrease in mean arterial pressure of ≥10 mmHg accompanied by symptoms such as nausea, dizziness, muscle cramps, and fainting (4). However, several alternative definitions based on nadir systolic blood pressure thresholds have also been proposed, leading to substantial inconsistency in prevalence estimates and clinical interpretation. Studies have shown that asymptomatic blood pressure drops may be equally dangerous, as lower nadir systolic blood pressure has been independently associated with increased mortality risk among hemodialysis patients (5).

The prevalence of IDH varies considerably across studies because of these definitional inconsistencies, ranging from 5% to 68.9% of dialysis sessions, although most evidence suggests that clinically meaningful IDH occurs in approximately 10–30% of sessions (6). Systematic reviews and international cohort studies continue to confirm IDH as a highly prevalent complication in maintenance hemodialysis populations worldwide. Recent studies from Europe, China, Cameroon, India, and Pakistan have reported high frequencies of IDH, particularly in resource-limited settings where dialysis infrastructure and monitoring systems are constrained (5,7,8). The pathophysiology of IDH is multifactorial and primarily results from excessive ultrafiltration exceeding plasma refilling capacity, leading to intravascular volume depletion and failure of cardiovascular compensatory mechanisms. Factors such as autonomic dysfunction, impaired vasomotor response, high

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ultrafiltration rates, and diabetic neuropathy significantly contribute to hemodynamic instability during dialysis sessions (9,11,12).

Several demographic and clinical risk factors increase the likelihood of IDH during hemodialysis. Advanced age, female sex, diabetes mellitus, low pre-dialysis blood pressure, inaccurate dry weight estimation, and high interdialytic weight gain are consistently identified as major predictors of hypotensive episodes (13,14). Recurrent IDH has serious consequences extending beyond temporary blood pressure reduction, including cerebral ischemia, cognitive decline, vascular access thrombosis, inadequate dialysis delivery, increased hospitalization, and higher mortality rates (13,15). Furthermore, IDH significantly impairs health-related quality of life (HRQoL), contributing to fatigue, dizziness, muscle cramps, reduced mobility, anxiety, and diminished physical functioning among hemodialysis patients (16). Preventive strategies such as dietary sodium restriction, cool dialysate, ultrafiltration profiling, adjustment of antihypertensive medications, and pharmacological agents like midodrine have shown varying degrees of effectiveness, although strong evidence from large randomized controlled trials remains limited (17,18).

Despite growing international evidence, substantial research gaps persist regarding IDH in low- and middle-income countries, particularly Pakistan. Existing literature indicates a shortage of local implementation research examining the prevalence, determinants, and management outcomes of IDH among Pakistani ESRD patients (18). Differences in patient demographics, healthcare infrastructure, dialysis practices, and resource availability may significantly influence IDH patterns within local dialysis units. Therefore, the present study aims to evaluate the prevalence and associated risk factors of IDH among maintenance hemodialysis patients using a multicenter cross-sectional design. By systematically assessing demographic variables, dialysis parameters, comorbidities, blood pressure changes, and ultrafiltration-related factors, the study seeks to generate local evidence that may support the development of targeted, cost-effective, and context-specific preventive strategies for improving patient outcomes in Pakistani dialysis centers (4,7,18).

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Literature Review

Haddiya et al. (2025) explained that intradialytic hypotension (IDH) is one of the most frequent and dangerous complications of hemodialysis, affecting nearly 8–40% of dialysis sessions in patients with end-stage renal disease (ESRD). The authors described IDH as a multifactorial condition caused by excessive ultrafiltration, rapid osmotic changes, impaired vascular resistance, diabetes mellitus, and cardiovascular disease. Their review emphasized that IDH may lead to myocardial stunning, cerebral ischemia, and multiorgan dysfunction, thereby worsening morbidity and mortality among dialysis patients. The study further highlighted the importance of individualized preventive strategies such as cooled dialysate, optimized ultrafiltration rates, nutritional management, bioimpedance spectroscopy, and artificial intelligence-based monitoring systems. The authors strongly recommended the development of a standardized definition of IDH to improve patient management and research consistency (13). Nkoyooyo et al. (2025) similarly reported that IDH remains highly prevalent in resource-limited settings, with a prevalence of 13.4% among Ugandan maintenance hemodialysis patients. Their findings demonstrated that diabetes mellitus, heart failure, and severe anemia were significant predictors of IDH, indicating that comorbid illnesses substantially contribute to hemodynamic instability during dialysis sessions (21).

Hou et al. (2025) investigated the relationship between IDH and physical functioning among maintenance hemodialysis patients and found that frequent IDH episodes were significantly associated with poor functional performance, reduced handgrip strength, decreased walking ability, and impaired mobility. The authors concluded that recurrent hypotensive episodes negatively affect patients' physical independence and quality of life, emphasizing the need for careful blood pressure control during dialysis sessions (22). Khan et al. (2025) conducted a Pakistani study at Khyber Teaching Hospital and reported that IDH occurred in 39.2% of maintenance hemodialysis patients, making it one of the most common intradialytic complications in local dialysis settings. The study found significant associations between IDH and modifiable factors such as interdialytic weight gain greater than 3 kg and ultrafiltration rates above 10 mL/kg/hour. Hospitalization rates were also

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markedly higher among patients experiencing IDH, demonstrating the serious clinical consequences of uncontrolled hypotension during dialysis (23). Ahmed et al. (2025) further supported these findings by documenting hypotension as the most common dialysis complication among ESRD patients in Pakistan, especially among females and patients with longer dialysis duration (8).

Hamada et al. (2025) evaluated blood volume change-guided ultrafiltration control (BV-UFC) and demonstrated that this technology significantly reduced the frequency of IDH episodes during hemodialysis by improving plasma refilling rates and maintaining better hemodynamic stability (24). Habas et al. (2025) also reviewed the pathophysiology and treatment of IDH and concluded that reduced effective circulating blood volume and decreased plasma tonicity are the primary contributors to hypotensive episodes during dialysis. Their review emphasized that prevention should remain the major therapeutic goal because current evidence regarding treatment strategies remains limited and inconsistent (25). Zhi et al. (2025) further explained that IDH adversely affects both physical and psychological dimensions of health-related quality of life (HRQoL), with studies showing increased risks of hospitalization, cardiovascular complications, and mortality among patients experiencing recurrent hypotension during dialysis sessions (16). Goel et al. (2025) similarly reported a very high prevalence of hypotensive episodes among ESRD patients undergoing maintenance hemodialysis and highlighted poor adherence to international dialysis guidelines as an important contributing factor (26).

Flythe et al. (2023) emphasized that IDH contributes significantly to cardiovascular disease, hospitalization, and mortality among hemodialysis patients and suggested that both patient education and provider training interventions may help reduce the burden of IDH in clinical practice (3). Hamrahian et al. (2023) further noted that IDH develops through complex interactions between patient-related factors such as age, diabetes, and cardiovascular disease and dialysis-related factors including high ultrafiltration rates and fluid shifts. The authors recommended individualized fluid management, ultrafiltration profiling, and future biomarker-based and artificial intelligence-supported predictive systems to improve prevention strategies (19). Maas et al. (2023) demonstrated

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that machine learning models can predict IDH episodes with high accuracy up to 75 minutes before occurrence, suggesting that real-time prediction systems may become valuable tools for preventing hypotensive complications during dialysis (34). Davenport et al. (2022) and Kanbay et al. (2020) both concluded that IDH is fundamentally caused by impaired vascular refilling, reduced cardiac output, autonomic dysfunction, and excessive ultrafiltration, while emphasizing the urgent need for evidence-based prevention strategies and consensus definitions to improve patient outcomes (6,10).

Materials and Methods

The present study used a cross-sectional research design to assess intradialytic hypotension (IDH) among patients undergoing maintenance hemodialysis. The study was conducted at Muhammad Sulman Khalid Hospital Lahore (MSK) over a period of four months after approval of the research synopsis. A total of 77 patients were included in the study, and the sample size was calculated using the standard prevalence formula: $n = Z^2 \times P \times (1 - P) / d^2$, where Z represented the confidence interval at 95%, P represented the expected prevalence of IDH, and d represented the margin of error or precision level. The cross-sectional design was considered appropriate for determining the prevalence and associated factors of IDH within the selected study population.

The inclusion criteria consisted of adult patients aged 18 years and above who were diagnosed with end-stage renal disease (ESRD) and had been receiving maintenance hemodialysis for at least three months. Patients with stable dialysis prescriptions, including unchanged dry weight, dialysate composition, and session duration, were included in the study to ensure consistency in dialysis-related parameters. Patients with advanced heart failure, unstable cardiac conditions, active infections, recent hospitalization, malignancy, or lower limb vascular deformities were excluded to minimize confounding variables and maintain participant safety during the research process. Clearly defined inclusion and exclusion criteria helped improve the validity and reliability of the study findings.

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Ethical approval for the study was obtained from Superior University before the initiation of data collection. Written informed consent was obtained from all participants after providing a clear explanation of the study objectives, procedures, risks, and benefits. Patient confidentiality was maintained by de-identifying personal information and securely storing all collected data. ESRD patients undergoing hemodialysis were treated as a vulnerable population, and every effort was made to minimize physical or psychological burden during participation. The study followed ethical principles ensuring participant welfare, justice, and voluntary participation throughout the research process.

Data collection involved obtaining baseline demographic, clinical, and laboratory information from medical records, including dialysis duration, comorbidities, ultrafiltration rate, interdialytic weight gain, and blood pressure measurements. Blood pressure was monitored regularly during dialysis sessions to identify episodes of intradialytic hypotension. All collected data were documented using standardized forms and analyzed using SPSS version 27. Descriptive statistics such as mean, standard deviation, frequencies, and percentages were used to summarize the variables. Chi-square tests were applied for categorical variables, while t-tests and ANOVA were used for continuous variables. Logistic regression analysis was conducted to identify independent predictors of IDH, and ROC curve analysis was used to evaluate the predictive accuracy of the statistical model.

Results

This cross-sectional study investigated 70 end-stage renal disease patients undergoing maintenance hemodialysis to determine the frequency and predictors of intradialytic hypotension (IDH). The findings demonstrated that IDH occurred in both genders with slightly higher frequency in males (68.6%) compared to females (60.0%), although this difference was not statistically meaningful. Overall, demographic and clinical characteristics such as gender, BMI, anemia status, nausea/vomiting during dialysis, hypoglycemia, and ultrafiltration rate did not show significant

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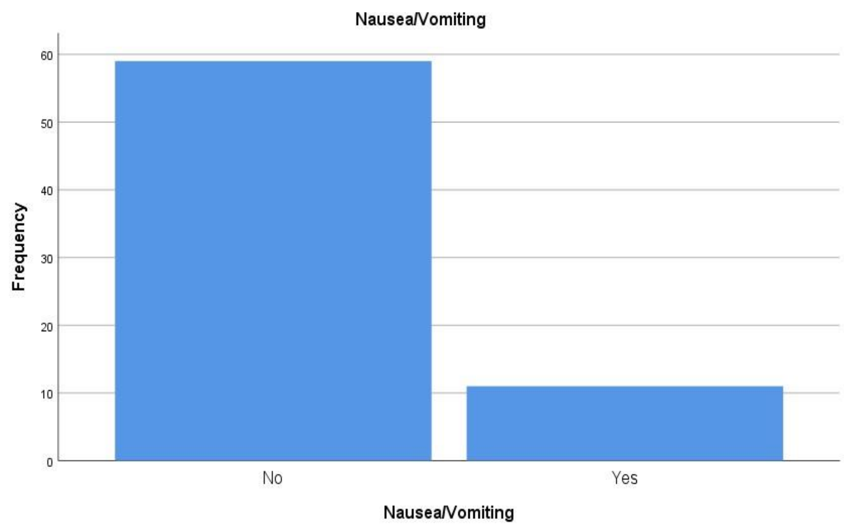
associations with IDH, indicating that no single isolated variable could reliably explain the occurrence of hypotensive episodes in this cohort.

Frequency of Hypoglycemia during Dialysis



The descriptive profile of participants showed a mean age of 51.66 years and a notably low mean BMI of 18.54, suggesting a generally undernourished or lean dialysis population. Hemodialysis duration averaged 2.22 years, while dialysis sessions were standardized at 4 hours with a fixed dialysate flow rate of 500 mL/min, ensuring procedural uniformity across all patients. Blood flow rates varied moderately, with a mean of 276.43 mL/min, and dialysis frequency ranged from 1 to 3 sessions per week. Despite this clinical variation, statistical testing confirmed that none of these baseline characteristics differed significantly between patients with and without IDH.

Frequency of Nausea/Vomiting

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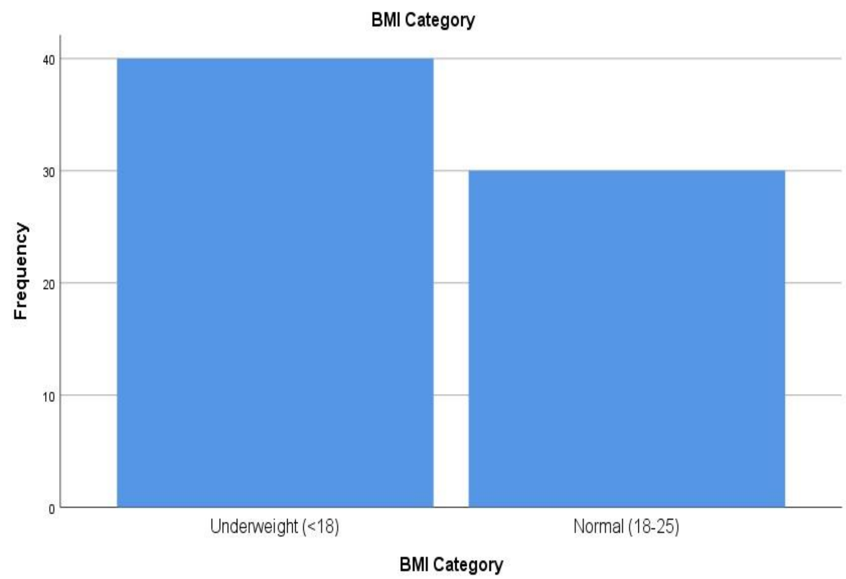

Inferential analysis using chi-square testing further supported the absence of strong categorical associations. Variables including gender, BMI category, anemia status, hypoglycemia during dialysis, nausea/vomiting, and high ultrafiltration all showed p-values greater than 0.05, indicating no statistically significant relationship with IDH. Similarly, one-way ANOVA results demonstrated that age, BMI, and duration of hemodialysis did not significantly differ between IDH and non-IDH groups, reinforcing the overall pattern that individual patient or dialysis-related factors alone were insufficient to predict hypotensive events.

Frequency of Anemia

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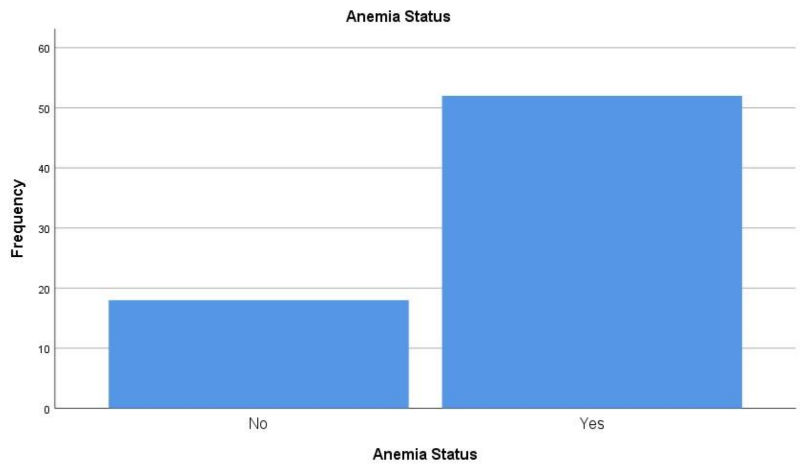

Despite the lack of significant associations in univariate and group comparisons, ROC curve analysis revealed a strong overall predictive capacity when variables were combined into a multivariate model. The model achieved an area under the curve (AUC) of 0.856, indicating good discriminatory performance in identifying patients at risk of IDH. Among individual predictors, age emerged as the only statistically significant factor with an AUC of 0.687, while blood flow rate, BMI, and dialysis duration showed weak or non-significant predictive value. This highlights that while single variables are limited in predictive utility, their combined interaction may still provide clinically useful risk stratification.

The findings suggest that intradialytic hypotension in this population is a multifactorial condition that cannot be attributed to isolated demographic or clinical variables. The absence of significant univariate associations contrasts with the strong performance of the combined predictive model, indicating that IDH likely results from complex interactions between patient physiology and dialysis parameters. These results support the need for integrated predictive approaches rather than reliance on single risk factors, and they emphasize the importance of composite models for improving early identification and prevention strategies in clinical practice.

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Discussion

This study evaluated the relationship between clinical and demographic variables and intradialytic hypotension (IDH) in 70 patients with end-stage renal disease undergoing maintenance hemodialysis. The cohort demonstrated a relatively high burden of IDH across both genders, with slightly higher prevalence in males, although the difference was not statistically meaningful. Overall patient characteristics such as low mean BMI, moderate dialysis duration, and uniform dialysis prescription suggest a relatively homogeneous clinical population. When interpreted against existing literature, the observed IDH burden aligns with widely reported variability in prevalence, which ranges from approximately 10% to 40% depending on definitions and whether outcomes are assessed per session or per patient, highlighting the influence of methodological differences on reported incidence.

Analysis of demographic factors showed no statistically significant association between gender, BMI, anemia status, nausea/vomiting, or hypoglycemia and the occurrence of IDH. These findings suggest that individual baseline characteristics alone may not be sufficient to explain hemodynamic instability during dialysis in this cohort. Although some variables such as hypoglycemia approached significance, overall chi-square results remained above the threshold for statistical significance. This pattern is consistent with evidence indicating that IDH is a multifactorial phenomenon rather than a condition driven by single isolated predictors, and that many commonly cited risk factors demonstrate inconsistent predictive strength when evaluated independently.

Further inferential testing using ANOVA confirmed that age, BMI, and duration of hemodialysis did not differ significantly between IDH and non-IDH groups, reinforcing the limited explanatory power of individual variables in isolation. Similarly, ultrafiltration rate and blood flow rate showed no statistically significant association with IDH despite being recognized in the literature as clinically relevant contributors. The absence of significant findings in these variables may be partly explained by restricted variability within the sample and the complex interaction between fluid removal dynamics, cardiovascular reserve, and patient-specific comorbidities. These results collectively

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emphasize that IDH cannot be reliably predicted using single clinical parameters alone in this population.

Despite weak performance of individual predictors, ROC curve analysis demonstrated strong discriminative ability of the combined predictive model, with an AUC of 0.856 indicating good overall accuracy in identifying patients at risk of IDH. Among individual variables, only age showed statistically significant predictive value, reflecting its established role in reduced cardiovascular reserve and autonomic dysfunction in dialysis patients. The superior performance of the combined model compared to individual variables highlights the importance of multivariable interaction in IDH prediction. Overall, the findings support the conclusion that intradialytic hypotension is best understood as a multifactorial condition, where integrated clinical models provide more meaningful predictive value than isolated risk factors.

CONCLUSION

This study found that while no single demographic or clinical variable, except for age, significantly predicted intradialytic hypotension on its own, the combined predictive model showed a strong discriminative capacity with an AUC of .856. Age emerged as a meaningful individual predictor, reinforcing that older ESRD patients carry a higher hemodynamic risk during hemodialysis. These findings suggest that multivariable risk assessment, even using basic clinical parameters, holds real clinical value for early identification and closer monitoring of IDH-prone patients in conventional hemodialysis settings.

This study had several limitations worth acknowledging. First, the sample size of 70 patients was relatively small, which reduced statistical power and may explain the non-significant results for variables like hypoglycemia and ultrafiltration rate, where near-significant or clinically plausible trends were observed. Second, data on hemodialysis duration was only available for 49 of the 70 participants, introducing potential bias in those specific analyses. Third, the study was conducted in a single center, limiting generalizability. Finally, several potentially important confounders, such as

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antihypertensive medication use, dialysate temperature, albumin levels, and cardiovascular comorbidities, were not included, which may have influenced IDH occurrence independently.

Future research should replicate this study with larger, multicenter samples to confirm the predictive role of age and test the combined model across diverse populations. Longitudinal designs would help clarify whether IDH risk evolves over dialysis duration. Clinically, dialysis units should adopt routine multivariable risk screening for older patients and those with low BMI. Variables such as serum albumin, antihypertensive medication timing, and ultrafiltration rate should be incorporated into future predictive models to improve sensitivity and specificity beyond what was achievable in this study.

REFERENCES

Global, regional, and national burden of chronic kidney disease in adults, 1990-2023, and its attributable risk factors: a systematic analysis for the Global Burden of Disease Study 2023.
Lancet. 2025;406(10518):2461-82.

Basit B, Sabir O. Incidence of Chronic Kidney Disease Stage 5 Hemodialysis Patients in the Month of December 2023–A Snapshot survey. Pakistan Journal of Kidney Diseases.
2024;8(1):9-12.

Veinot TC, Gillespie B, Argentina M, Bragg-Gresham J, Chatoth D, Collins Damron K, et al. Enhancing the Cardiovascular Safety of Hemodialysis Care Using Multimodal Provider Education and Patient Activation Interventions: Protocol for a Cluster Randomized Controlled Trial. JMIR Res Protoc. 2023;12:e46187.

Lin CJ, Chen YY, Pan CF, Wu V, Wu CJ. Dataset supporting blood pressure prediction for the management of chronic hemodialysis. Sci Data. 2019;6(1):313.

Zhi M, Zeng Y, Chen C, Deng S, Liu Y, Huang Y, et al. The relationship between intradialytic hypotension and health-related quality of life in patients undergoing hemodialysis: a cross-sectional study. Scientific Reports. 2025;15(1):11532.

Pakistan Journal of Medical & Cardiological Review
https://pakjmcr.com/index.php/1/about
Online ISSN 3007-2387
Print ISSN 3007-2379
Riaz et al - 2026
DOI: http://doi.org/10.5281/zenodo.20486204

Davenport A. Why is Intradialytic Hypotension the Commonest Complication of Outpatient Dialysis Treatments? Kidney Int Rep. 2023;8(3):405-18.

Kuipers J, Verboom LM, Ipema KJR, Paans W, Krijnen WP, Gaillard C, et al. The Prevalence of Intradialytic Hypotension in Patients on Conventional Hemodialysis: A Systematic Review with Meta-Analysis. Am J Nephrol. 2019;49(6):497-506.

Ahmad T, Jan MS, Zaidi M, Khan ZA, Sultan S. Spectrum of Intradialytic Complications in End-Stage Renal Disease Patients on Maintenance Hemodialysis. Journal of Health, Wellness and Community Research. 2025:e743-e.

Kanbay M, Ertuglu LA, Afsar B, Ozdogan E, Siriopol D, Covic A, et al. An update review of intradialytic hypotension: concept, risk factors, clinical implications and management.

Clin Kidney J. 2020;13(6):981-93.

Kanbay M, Ertuglu LA, Afsar B, Ozdogan E, Siriopol D, Covic A, et al. An update review of intradialytic hypotension: concept, risk factors, clinical implications and management.

Clinical kidney journal. 2020;13(6):981-93.

van der Sande FM, Dekker MJ, Leunissen KML, Kooman JP. Novel Insights into the Pathogenesis and Prevention of Intradialytic Hypotension. Blood Purif. 2018;45(1-3):230-5.

Chou JA, Kalantar-Zadeh K, Mathew AT. A brief review of intradialytic hypotension with a focus on survival. Semin Dial. 2017;30(6):473-80.

Haddiya I, Simanjuntak G, Ramdani S. Updates in the management of intradialytic hypotension: Emerging strategies and innovations. World J Nephrol. 2025;14(4):109168. 14. da Hora Passos R, Coelho FO, Caldas JR, Dosde Santos GalvãoMelo EB, de Carvalho Farias AM, Messeder OHC, et al. Predicting intradialytic hypotension in critically ill patients undergoing intermittent hemodialysis: a prospective observational study. Intensive Care Med Exp. 2024;12(1):82.

Pakistan Journal of Medical & Cardiological Review
https://pakjmcr.com/index.php/1/about
Online ISSN 3007-2387
Print ISSN 3007-2379
Riaz et al - 2026
DOI: http://doi.org/10.5281/zenodo.20486204

Veinot TC, Gillespie B, Argentina M, Bragg-Gresham J, Chatoth D, Damron KC, et al. Enhancing the cardiovascular safety of hemodialysis care using multimodal provider education and patient activation interventions: protocol for a cluster randomized controlled trial. JMIR Research Protocols. 2023;12(1):e46187.

Zhi M, Zeng Y, Chen C, Deng S, Liu Y, Huang Y, et al. The relationship between intradialytic hypotension and health-related quality of life in patients undergoing hemodialysis: a cross-sectional study. Sci Rep. 2025;15(1):11532.

Peyronel F, Parenti E, Fenaroli P, Benigno GD, Rossi GM, Maggiore U, et al. Integrated strategies to prevent intradialytic hypotension: research protocol of the DialHypot study, a prospective randomised clinical trial in hypotension-prone haemodialysis patients. BMJ Open.
2020;10(7):e036893.

AlRashed H, Miele J, Prasad J, Adenikinju D, Iloegbu C, Patena J, et al. Systematic review of end stage renal disease in Pakistan: Identifying implementation research outcomes.
Plos one. 2023;18(12):e0296243.

Hamrahian SM, Vilayet S, Herberth J, Fülöp T. Prevention of Intradialytic Hypotension in Hemodialysis Patients: Current Challenges and Future Prospects. Int J Nephrol Renovasc Dis.
2023;16:173-81.

Assimon MM, Flythe JE. Definitions of intradialytic hypotension. Semin Dial. 2017;30(6):464-72.

Nkoyooyo D, Kiggundu D, Asiimwe D, Lubwama C, Ssentongo M, Mwebesa D, et al.
Prevalence and associated factors of intradialytic hypotension among patients with kidney failure on maintenance hemodialysis at Kiruddu National Referral Hospital, Uganda. BMC Nephrol. 2025;27(1):38.

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DOI: http://doi.org/10.5281/zenodo.20486204

Hou CQ, Luo XJ, Xu QJ, Zhi M, Liu M, Deng SY, et al. Association between intradialytic hypotension and physical function in patients undergoing maintenance hemodialysis: a multicenter cross-sectional study. Front Med (Lausanne). 2025;12:1655597. 23. Khan NL, Ilyas K, Zubair M, Khan F, Banaras F. Clinical Implications of Intradialytic Hypotension: Impact on Morbidity and Mortality in Dialysis Patients. Indus Journal of Bioscience Research. 2025;3(9):1-4.

Hamada S, Hata M, Furukawa S, Yamamoto S. Effectiveness of blood volume changeguided ultrafiltration control (BV-UFC) in hemodialysis: a crossover comparative study. Clin Kidney J. 2025;18(5):sfaf141.

Habas E, Rayani A, Habas A, Farfar K, Habas E, Alarbi K, et al. Intradialytic hypotension pathophysiology and therapy update: Review and update. Blood pressure. 2025(justaccepted):1-18.

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

Jeon J, Lim YJ, Kim BY, Choi JY, Do JY, Lee JE, et al. Midodrine and clinical outcomes in patients on maintenance hemodialysis. Sci Rep. 2025;15(1):23600.

Wu Y, Lu J, Wang T, Zhu X, Xue J, You L. Association of frequent intradialytic hypotension with the clinical outcomes of patients on hemodialysis: a prospective cohort study.

Ren Fail. 2024;46(1):2296612.

Xiang Y, Ma G, Yang Q, Cao M, Xu W, Li L, et al. External validation of the prediction model of intradialytic hypotension: a multicenter prospective cohort study. Ren Fail. 2024;46(1):2322031.

Mambelli E, Grandi F, Santoro A. Comparison of blood volume biofeedback hemodialysis and conventional hemodialysis on cardiovascular stability and blood pressure control in hemodialysis patients: a systematic review and meta-analysis of randomized controlled trials. J Nephrol. 2024;37(4):897-909.

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Chen TY, Hsieh MH, Su FY, Li CY, Wang MC, Tseng CC, et al. Risk of intradialytic hypotension among different antihypertensives in haemodialysis patients. Clin Kidney J.

2025;18(6):sfaf159.

Zhu Y, Li J, Lu H, Shi Z, Wang X. Effect of hemodiafiltration and hemodialysis on mortality of patients with end-stage kidney disease: a meta-analysis. BMC Nephrol.

2024;25(1):372.

Wang J, Yao J, Zhu X, Wang T, Lu J, Wei Q, et al. Impact of frequent intradialytic hypotension on quality of life in patients undergoing hemodialysis. BMC Nephrol.

2023;24(1):209.

Zhang H, Wang LC, Chaudhuri S, Pickering A, Usvyat L, Larkin J, et al. Real-time prediction of intradialytic hypotension using machine learning and cloud computing infrastructure. Nephrol Dial Transplant. 2023;38(7):1761-9.

Timofte D, Tanasescu M-D, Balan DG, Tulin A, Stiru O, Vacaroiu IA, et al.

Management of acute intradialytic cardiovascular complications: Updated overview.

Experimental and Therapeutic Medicine. 2021;21(3):282.

Sars B, van der Sande FM, Kooman JP. Intradialytic Hypotension: Mechanisms and Outcome. Blood Purif. 2020;49(1-2):158-67.

Canaud B, Kooman JP, Selby NM, Taal MW, Francis S, Maierhofer A, et al. DialysisInduced Cardiovascular and Multiorgan Morbidity. Kidney Int Rep. 2020;5(11):1856-69.

Reeves PB, Mc Causland FR. Mechanisms, Clinical Implications, and Treatment of Intradialytic Hypotension. Clin J Am Soc Nephrol. 2018;13(8):1297-303.

Seo Y, Jeung S, Kang SM, Yang WS, Kim H, Kim SB. Use of fludrocortisone for intradialytic hypotension. Kidney Res Clin Pract. 2018;37(1):85-8.

Kuipers J, Verboom LM, Ipema KJ, Paans W, Krijnen WP, Gaillard CA, et al. The prevalence of intradialytic hypotension in patients on conventional hemodialysis: a systematic review with meta-analysis. American journal of nephrology. 2019;49(6):497-506.

Vol. 5 No. 2 (2026)
Pakistan Journal of Medical & Cardiological Review
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Print ISSN 3007-2379
Riaz et al - 2026
DOI: http://doi.org/10.5281/zenodo.20486204

Li Z, Yang L, Xi Z, Yi W, Zeng X, Ma D, et al. Prediction models for intradialytic hypotension in hemodialysis patients: A protocol for systematic review and critical appraisal.

PLoS One. 2024;19(9):e0310191.

Schwartz D, Gorman AH, Nakamoto J, McKay T. Popularity, social acceptance, and aggression in adolescent peer groups: links with academic performance and school attendance.

Developmental psychology. 2006;42(6):1116.

Ozen N, Cepken T. Intradialytic hypotension prevalence, influencing factors, and nursing interventions: prospective results of 744 hemodialysis sessions. Ir J Med Sci. 2020;189(4):14716.

Chou JA, Streja E, Nguyen DV, Rhee CM, Obi Y, Inrig JK, et al. Intradialytic hypotension, blood pressure changes and mortality risk in incident hemodialysis patients.

Nephrol Dial Transplant. 2018;33(1):149-59.

Bae TW, Kim MS, Park JW, Kwon KK, Kim KH. Multilayer Perceptron-Based RealTime Intradialytic Hypotension Prediction Using Patient Baseline Information and Heart-Rate Variation. Int J Environ Res Public Health. 2022;19(16).