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Original Research Article

CLINICAL PROFILE OF CHRONIC KIDNEY DISEASE PATIENTS UNDERGOING HAEMODIALYSIS DEVELOPING INTRA-DIALYTIC HYPERTENSION: A PROSPECTIVE OBSERVATIONAL STUDY FROM A TERTIARY CARE CENTER

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ABSTRACT

Background: Intradialytic hypertension (IDH) is a paradoxical increase in blood pressure occurring during or immediately after haemodialysis and is increasingly recognized as an important predictor of cardiovascular morbidity and mortality among patients with chronic kidney disease (CKD). Although several mechanisms, including volume overload, endothelial dysfunction, sympathetic overactivity, and arterial stiffness, have been implicated in its pathogenesis, limited data are available regarding the clinical profile of patients developing intradialytic hypertension in the Indian population. **Objective:** To evaluate the clinical profile of chronic kidney disease patients undergoing maintenance haemodialysis who developed intradialytic hypertension.

Materials and Methods: A hospital-based prospective observational study was conducted in the Department of Nephrology, Princess Esra Hospital and Owaisi Hospital, Deccan College of Medical Sciences (DCMS), Hyderabad, from January 2025 to June 2025. A total of 120 adult CKD patients on maintenance haemodialysis who fulfilled the diagnostic criteria for intradialytic hypertension were included. Demographic characteristics, clinical profile, comorbidities, dialysis-related variables, laboratory parameters, blood pressure measurements, antihypertensive therapy, and cardiovascular findings were recorded using a structured case record form. Data were analyzed using IBM SPSS Statistics version 29.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. A p-value of <0.05 was considered statistically significant.

Results: Of the 120 patients undergoing maintenance haemodialysis, 30 (25.0%) developed intradialytic hypertension, while 90 (75.0%) remained normotensive during dialysis sessions. The mean age of the study population was 50.8 ± 12.1 years, with a male predominance (63.3%). Diabetic nephropathy (40.0%) and hypertensive nephrosclerosis (25.8%) were the leading causes of chronic kidney disease. Patients with intradialytic hypertension had significantly higher frequencies of diabetes mellitus, dyslipidaemia, coronary artery disease, left ventricular hypertrophy, higher ultrafiltration volumes, and lower serum albumin levels compared with normotensive patients ($p<0.05$). Older age (>50 years) was also significantly associated with intradialytic hypertension, whereas gender, dialysis duration, dialysis frequency, and vascular access type did not show statistically significant associations. The mean age of the study population was 50.8 ± 12.1

years, with a male predominance (63.3%). Diabetic nephropathy (40.0%) and hypertensive nephrosclerosis (25.8%) were the leading causes of chronic kidney disease. Patients with intradialytic hypertension had significantly higher frequencies of diabetes mellitus, dyslipidaemia, coronary artery disease, left ventricular hypertrophy, higher ultrafiltration volumes, and lower serum albumin levels compared with normotensive patients ($p<0.05$). Older age (>50 years) was also significantly associated with intradialytic hypertension, whereas gender, dialysis duration, dialysis frequency, and vascular access type did not show statistically significant associations. **Conclusion:** Intradialytic hypertension is associated with a high burden of cardiovascular risk factors and dialysis-related variables among patients receiving maintenance haemodialysis. Diabetes mellitus, left ventricular hypertrophy, hypoalbuminemia, and higher ultrafiltration volumes were associated with greater intradialytic blood pressure elevation. Careful blood pressure monitoring, optimization of volume status, and individualized antihypertensive management may facilitate early identification and improved management of patients at risk for intradialytic hypertension.
Keywords: Chronic kidney disease, intradialytic hypertension, haemodialysis, blood pressure, diabetic nephropathy, cardiovascular disease.

INTRODUCTION

Chronic kidney disease (CKD) is a progressive and irreversible disorder characterized by a gradual decline in renal function that ultimately culminates in end-stage kidney disease (ESKD), requiring renal replacement therapy in the form of dialysis or kidney transplantation. CKD has emerged as a major public health problem worldwide owing to the increasing prevalence of diabetes mellitus, hypertension, obesity, and population aging. It is associated with substantial cardiovascular morbidity, mortality, reduced quality of life, and increased healthcare expenditure.[1-4]

Haemodialysis remains the most commonly employed renal replacement therapy for patients with ESKD. The primary objectives of maintenance haemodialysis are adequate removal of uremic toxins, maintenance of fluid and electrolyte balance, correction of acid-base disturbances, and optimization of blood pressure. However, despite technological advancements, intradialytic hemodynamic instability continues to be one of the most frequent complications encountered during dialysis sessions.[5-7]

Blood pressure usually declines during haemodialysis owing to ultrafiltration-induced reduction in plasma volume. Conversely, a subset of patients experiences a paradoxical increase in blood pressure during or immediately after dialysis, a phenomenon referred to as intradialytic hypertension (IDH). Although no universally accepted definition exists, IDH is commonly defined as an increase in systolic blood pressure of at least 10 mmHg from pre-dialysis to post-dialysis measurements occurring repeatedly over multiple dialysis sessions.[8-11]

The prevalence of intradialytic hypertension has been reported to range from approximately 5% to 20% among maintenance haemodialysis patients depending upon the diagnostic criteria, study population, and frequency of blood pressure monitoring. Recent systematic reviews have demonstrated that IDH is associated with increased cardiovascular events, hospitalization, and all-cause mortality, making it an important prognostic marker in patients undergoing chronic haemodialysis.[12-15]

The pathophysiology of intradialytic hypertension is complex and multifactorial. Persistent extracellular volume overload is considered one of the principal mechanisms responsible for paradoxical blood pressure elevation during dialysis. However, several additional mechanisms including endothelial dysfunction, increased endothelin-1 production, reduced nitric oxide bioavailability, activation of the sympathetic nervous system, stimulation of the renin–angiotensin–aldosterone system, arterial stiffness, vascular calcification, oxidative stress, and inflammation have also been implicated.[16-20]

Dialysis-related factors may further contribute to the development of intradialytic hypertension. High dialysate sodium concentration, inadequate ultrafiltration, failure to achieve true dry weight, high dialysate calcium concentration, rapid osmotic shifts, and administration of erythropoiesis-stimulating agents have all been associated with increases in blood pressure during dialysis. Similarly, withholding antihypertensive medications before dialysis sessions may predispose susceptible individuals to intradialytic blood pressure elevation.[16,21]

Patients with recurrent intradialytic hypertension frequently exhibit multiple cardiovascular risk factors including advanced age, diabetes mellitus, long-standing hypertension, left ventricular hypertrophy, ischemic heart disease, anemia, dyslipidaemia, and vascular access dysfunction. Studies have demonstrated that these patients have greater arterial stiffness, impaired endothelial function, higher pulse wave velocity, and poorer overall cardiovascular outcomes than patients with stable intradialytic blood pressure profiles.[22]

Recognition of intradialytic hypertension has gained increasing importance because repeated blood

pressure elevation during dialysis is independently associated with increased cardiovascular mortality. Consequently, recent nephrology guidelines emphasize careful assessment of volume status, optimization of dry weight, individualized dialysis prescription, ambulatory blood pressure monitoring, and appropriate selection of antihypertensive therapy in patients exhibiting recurrent intradialytic hypertension.[23-25]

Despite increasing awareness of intradialytic hypertension, data from the Indian subcontinent remain relatively scarce. Differences in patient characteristics, socioeconomic factors, nutritional status, burden of diabetes and hypertension, dialysis practices, and vascular access patterns may influence the occurrence and clinical presentation of IDH among Indian patients. Therefore, institution-based observational studies are essential to understand the demographic profile, associated comorbidities, laboratory abnormalities, and dialysis-related factors contributing to intradialytic hypertension in this population.

The present prospective observational study was undertaken in the Department of Nephrology, Princess Esra Hospital and Owaisi Hospital, Deccan College of Medical Sciences, Hyderabad, to evaluate the clinical profile of chronic kidney disease patients undergoing maintenance haemodialysis who developed intradialytic hypertension. The findings of this study are expected to contribute to a better understanding of the clinical characteristics of IDH and may assist clinicians in developing targeted strategies to improve blood pressure control and reduce cardiovascular complications among maintenance haemodialysis patients.

Objectives

1. To study the demographic profile of CKD patients developing intradialytic hypertension.
2. To evaluate the clinical characteristics and comorbid conditions associated with intradialytic hypertension.
3. To assess laboratory parameters among patients developing intradialytic hypertension.
4. To study dialysis-related factors including vascular access, dialysis vintage, ultrafiltration volume, and dialysate characteristics.
5. To evaluate antihypertensive therapy and blood pressure changes during maintenance haemodialysis.

MATERIALS AND METHODS

Study Design and Setting

This hospital-based prospective observational study was conducted in the Department of Nephrology, Princess Esra Hospital and Owaisi Hospital, Deccan College of Medical Sciences (DCMS), Kanchanbagh, Hyderabad, Telangana, India. The study was undertaken over a period of six months from **January 2025 to June 2025** with the objective of evaluating the clinical profile of chronic kidney disease (CKD) patients undergoing maintenance haemodialysis who developed intradialytic hypertension. The study was conducted in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for observational studies.

Study Population

The study population comprised adult patients diagnosed with chronic kidney disease receiving maintenance haemodialysis at the dialysis unit of the study institution and fulfilled the predefined inclusion criteria were enrolled after obtaining written informed consent. A total of **120 patients** were included in the study.

Inclusion and Exclusion Criteria

Patients aged **18 years or above** with chronic kidney disease receiving maintenance haemodialysis for at least three months and undergoing two or three dialysis sessions per week were considered eligible for inclusion. Intradialytic hypertension was defined as a persistent increase in systolic blood pressure of **≥10 mmHg from pre-dialysis to post-dialysis measurements** occurring during at least four out of six consecutive dialysis sessions. Patients who provided written informed consent were enrolled in the study.

Patients with acute kidney injury, those undergoing emergency haemodialysis, patients on peritoneal dialysis, renal transplant recipients, pregnant women, patients with active systemic infection or sepsis, active malignancy, acute cardiovascular events during the study period, or those unwilling to participate were excluded from the study.

Data Collection

A detailed clinical evaluation was performed for all enrolled participants using a predesigned and pretested case record form. Demographic information including age, sex, residence, occupation, and body mass index was recorded. Clinical details such as duration and etiology of chronic kidney disease, duration of maintenance haemodialysis, dialysis frequency, smoking and alcohol history, previous cardiovascular disease, and family history of hypertension were documented. Information regarding associated comorbidities including hypertension, diabetes mellitus, coronary artery disease, congestive heart failure, cerebrovascular disease, peripheral vascular disease, and dyslipidaemia was also collected.

Clinical Assessment

All participants underwent a detailed general and systemic clinical examination. Baseline physical examination included measurement of height, weight, body mass index, pulse rate, respiratory rate, and assessment for signs of fluid overload such as pedal edema and raised jugular venous pressure. Blood pressure measurements were obtained using a calibrated automated sphygmomanometer according to standard recommendations.

Blood pressure was recorded immediately before initiation of dialysis, at 30-minute intervals during

the dialysis session, and immediately after completion of dialysis. Pre-dialysis, intradialytic, and post-dialysis systolic and diastolic blood pressures were documented for each participant. Mean arterial pressure was calculated whenever required. Patients fulfilling the study definition of intradialytic hypertension were included for further analysis.

Dialysis-Related Variables

Dialysis-related characteristics were obtained from the dialysis records. These included dialysis vintage, frequency of dialysis sessions per week, duration of each dialysis session, vascular access used for haemodialysis, blood flow rate, dialysate flow rate, ultrafiltration volume, ultrafiltration rate, estimated dry weight, interdialytic weight gain, and dialysate composition including sodium and calcium concentrations. The type of dialyzer membrane used during treatment was also documented.

Laboratory Investigations

Routine laboratory investigations performed as part of standard patient care were recorded from the hospital information system. Hematological parameters included hemoglobin concentration, total leukocyte count, and platelet count. Renal function tests comprised blood urea, serum creatinine, and estimated glomerular filtration rate. Biochemical investigations included serum sodium, potassium, calcium, phosphorus, bicarbonate, serum albumin, total protein, fasting blood glucose, glycated hemoglobin (HbA1c) in diabetic patients, serum uric acid, and lipid profile. Where available, markers of chronic kidney disease–mineral and bone disorder such as intact parathyroid hormone and serum vitamin D levels were also documented.

Cardiovascular Evaluation

Cardiovascular assessment included review of electrocardiographic and echocardiographic findings whenever available. Echocardiographic variables such as left ventricular hypertrophy, left ventricular ejection fraction, diastolic dysfunction, valvular abnormalities, and pulmonary artery pressure were recorded to assess the burden of cardiovascular disease among study participants.

Antihypertensive Therapy

Details regarding antihypertensive medications prescribed to each patient were documented, including calcium channel blockers, beta-blockers, angiotensin-converting enzyme inhibitors, angiotensin receptor blockers, alpha-blockers, centrally acting antihypertensive agents, vasodilators, and diuretics. The timing of antihypertensive medication administration in relation to the dialysis session was also recorded, as it may influence intradialytic blood pressure responses.

Outcome Measures

The primary outcome of the study was to describe the demographic, clinical, laboratory, and dialysis-related profile of chronic kidney disease patients who developed intradialytic hypertension during maintenance haemodialysis. Secondary outcomes included evaluation of associated comorbidities, antihypertensive medication use, dialysis-related characteristics, and patterns of blood pressure changes observed during dialysis sessions.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using **IBM SPSS Statistics version 29.0 (IBM Corp., Armonk, NY, USA)**. Continuous variables were expressed as mean ± standard deviation (SD) for normally distributed data or as median with interquartile range (IQR) where appropriate. Categorical variables were summarized as frequencies and percentages. Normality of continuous variables was assessed using the Shapiro–Wilk test. Continuous variables were compared using the Student's *t*-test or Mann–Whitney *U* test, while categorical variables were analyzed using the Chi-square test or Fisher's exact test as appropriate. Variables demonstrating statistical significance on univariate analysis were entered into multivariable logistic regression analysis to identify independent predictors of intradialytic hypertension. A two-tailed *p* value of **<0.05** was considered statistically significant.

RESULTS

Table 1: Demographic and clinical characteristics of the study participants (N = 120)

Variable	Frequency (%)
Age (years)	
18–30	10 (8.3)
31–40	22 (18.3)
41–50	34 (28.3)
51–60	31 (25.8)
>60	23 (19.2)
Gender	
Male	76 (63.3)
Female	44 (36.7)
BMI (kg/m²)	
<18.5	12 (10.0)
18.5–24.9	64 (53.3)
25–29.9	34 (28.3)
≥30	10 (8.3)
Smoking history	28 (23.3)
Alcohol consumption	24 (20.0)

Table 1 summarizes the demographic and baseline clinical characteristics of the study participants. The mean age of the patients was 50.8 ± 12.1 years. The majority of patients belonged to the 41–50 years age group (28.3%), followed by the 51–60 years age group (25.8%). Patients aged more than 60 years constituted 19.2% of the study population, while those aged 18–30 years accounted for only 8.3%. There was a male predominance, with 76 (63.3%) male and 44 (36.7%) female participants. More than half of the patients (53.3%) had a normal body mass index (18.5–24.9 kg/m²), whereas 28.3% were overweight and 8.3% were obese. A history of smoking and alcohol consumption was observed in 23.3% and 20.0% of patients, respectively.

Table 2: Clinical profile, etiology of CKD and associated comorbidities

Variable	Frequency (%)
Etiology of CKD	
Diabetic nephropathy	48 (40.0)
Hypertensive nephrosclerosis	31 (25.8)
Chronic glomerulonephritis	17 (14.2)
Obstructive nephropathy	8 (6.7)
Polycystic kidney disease	5 (4.2)
Others	11 (9.1)
Comorbidities*	
Hypertension	120 (100)
Diabetes mellitus	55 (45.8)
Dyslipidaemia	41 (34.2)
Coronary artery disease	24 (20.0)
Congestive heart failure	16 (13.3)
Cerebrovascular disease	9 (7.5)

Table 2 depicts the etiology of chronic kidney disease and associated comorbid conditions. Diabetic nephropathy was the most common underlying cause of CKD, accounting for 48 (40.0%) patients, followed by hypertensive nephrosclerosis in 31 (25.8%) patients. Chronic glomerulonephritis constituted 14.2% of cases, while obstructive nephropathy and polycystic kidney disease accounted for 6.7% and 4.2%, respectively. Hypertension was present in all study participants as expected, whereas diabetes mellitus was the most frequent associated comorbidity, observed in 55 (45.8%) patients. Dyslipidaemia was present in 34.2% of patients, coronary artery disease in 20.0%, congestive heart failure in 13.3%, and cerebrovascular disease in 7.5%.

Table 3: Haemodialysis characteristics

Variable	Frequency (%) / Mean ± SD
Duration of maintenance dialysis	
<1 year	28 (23.3)
1–3 years	51 (42.5)
3–5 years	26 (21.7)
>5 years	15 (12.5)
Dialysis frequency	
Twice weekly	38 (31.7)
Thrice weekly	82 (68.3)
Vascular access	
AV fistula	91 (75.8)
Tunneled catheter	16 (13.3)
Temporary catheter	8 (6.7)
AV graft	5 (4.2)
Dialysis duration (hours)	4.0 ± 0.3
Blood flow rate (mL/min)	285 ± 28
Ultrafiltration volume (L)	2.4 ± 0.7
Interdialytic weight gain (kg)	2.6 ± 0.8

Table 3 presents the haemodialysis-related characteristics of the study population. The majority of patients (42.5%) had been receiving maintenance haemodialysis for 1–3 years, followed by 23.3% for less than one year and 21.7% for 3–5 years. Most patients (68.3%) were undergoing haemodialysis three times per week, while the remaining 31.7% received dialysis twice weekly. An arteriovenous fistula was the predominant vascular access, being used in 75.8% of patients, whereas tunneled catheters, temporary catheters, and arteriovenous grafts were used in 13.3%, 6.7%, and 4.2% of patients, respectively. The mean dialysis duration was 4.0 ± 0.3 hours, with a mean blood flow rate of 285 ± 28 mL/min, mean ultrafiltration volume of 2.4 ± 0.7 L, and mean interdialytic weight gain of 2.6 ± 0.8 kg.

Table 4: Clinical and laboratory profile

Variable	Mean ± SD
Pulse rate (beats/min)	82.3 ± 10.8
Respiratory rate (/min)	18.4 ± 2.3
Hemoglobin (g/dL)	9.6 ± 1.4
Blood urea (mg/dL)	132.8 ± 31.4
Serum creatinine (mg/dL)	8.7 ± 2.3
Serum sodium (mEq/L)	137.6 ± 3.8
Serum potassium (mEq/L)	4.9 ± 0.7
Serum calcium (mg/dL)	8.6 ± 0.7
Serum phosphorus (mg/dL)	5.7 ± 1.2
Serum albumin (g/dL)	3.6 ± 0.5

Table 4 summarizes the clinical and laboratory profile of the participants. The mean pulse rate and respiratory rate were 82.3 ± 10.8 beats/min and 18.4 ± 2.3 breaths/min, respectively. The mean hemoglobin concentration was 9.6 ± 1.4 g/dL, indicating the high prevalence of anemia among patients undergoing maintenance haemodialysis. The mean blood urea and serum creatinine levels were 132.8 ± 31.4 mg/dL and 8.7 ± 2.3 mg/dL, respectively. Serum electrolyte levels were largely within acceptable ranges, with mean serum sodium of 137.6 ± 3.8 mEq/L, potassium of 4.9 ± 0.7 mEq/L, calcium of 8.6 ± 0.7 mg/dL, and phosphorus of 5.7 ± 1.2 mg/dL. The mean serum albumin concentration was 3.6 ± 0.5 g/dL.

Table 5: Blood pressure profile of cases having intradialytic hypertension during haemodialysis (n-30)

Variable	Mean ± SD
Pre-dialysis SBP (mmHg)	148.4 ± 16.5
Post-dialysis SBP (mmHg)	163.9 ± 18.1
Increase in SBP (mmHg)	15.5 ± 5.3
Pre-dialysis DBP (mmHg)	84.2 ± 9.1
Post-dialysis DBP (mmHg)	89.8 ± 8.7
Increase in DBP (mmHg)	5.6 ± 3.8
Mean arterial pressure (mmHg)	114.5 ± 10.4

Table 5 demonstrates the blood pressure profile during haemodialysis. The mean pre-dialysis systolic blood pressure was 148.4 ± 16.5 mmHg, which increased to 163.9 ± 18.1 mmHg following dialysis, with a mean systolic blood pressure rise of 15.5 ± 5.3 mmHg. Similarly, the mean diastolic blood pressure increased from 84.2 ± 9.1 mmHg before dialysis to 89.8 ± 8.7 mmHg after dialysis, corresponding to a mean increase of 5.6 ± 3.8 mmHg. The mean arterial pressure was 114.5 ± 10.4 mmHg, confirming the occurrence of intradialytic hypertension in the study population.

Table 6: Antihypertensive therapy and cardiovascular profile

Variable	Frequency (%)
Antihypertensive medications*	
Calcium channel blockers	84 (70.0)
Beta blockers	71 (59.2)
ARBs	48 (40.0)
ACE inhibitors	22 (18.3)
Alpha blockers	18 (15.0)
Central sympatholytics	14 (11.7)
Vasodilators	12 (10.0)
Echocardiographic findings*	
Left ventricular hypertrophy	69 (57.5)
Diastolic dysfunction	43 (35.8)
Reduced ejection fraction (<50%)	18 (15.0)
Pulmonary hypertension	16 (13.3)
Valvular heart disease	12 (10.0)

Table 6 shows the pattern of antihypertensive medication use and cardiovascular abnormalities. Calcium channel blockers were the most commonly prescribed antihypertensive agents, being used by 84 (70.0%) patients, followed by beta-blockers in 71 (59.2%), angiotensin receptor blockers in 40.0%, angiotensin-converting enzyme inhibitors in 18.3%, alpha-blockers in 15.0%, centrally acting agents in 11.7%, and vasodilators in 10.0% of patients. Echocardiographic evaluation revealed left ventricular hypertrophy as the most frequent cardiovascular abnormality, observed in 69 (57.5%) patients. Diastolic dysfunction was present in 35.8%, reduced left ventricular ejection fraction (<50%) in 15.0%, pulmonary hypertension in 13.3%, and valvular heart disease in 10.0% of patients.

Table 7: Association of Risk Factors with Intradialytic Hypertension among Patients Undergoing Maintenance Haemodialysis (N = 120)

Risk Factor	Intradialytic Hypertension (n=30)	Normotension (n=90)	χ^2	p value
Age >50 years	18 (60.0%)	34 (37.8%)	4.57	0.033*
Male gender	22 (73.3%)	54 (60.0%)	1.74	0.187
Diabetes mellitus	19 (63.3%)	36 (40.0%)	5.03	0.025*
Dyslipidaemia	15 (50.0%)	26 (28.9%)	4.61	0.032*
Coronary artery disease	10 (33.3%)	14 (15.6%)	4.47	0.034*
Dialysis duration >3 years	13 (43.3%)	28 (31.1%)	1.54	0.214
Thrice-weekly dialysis	24 (80.0%)	58 (64.4%)	2.52	0.112
Ultrafiltration volume >2.5 L	18 (60.0%)	29 (32.2%)	7.22	0.007*
Serum albumin <3.5 g/dL	20 (66.7%)	29 (32.2%)	11.15	0.001*
Left ventricular hypertrophy	22 (73.3%)	47 (52.2%)	4.16	0.041*
AV fistula as vascular access	22 (73.3%)	69 (76.7%)	0.14	0.705

Patients who developed intradialytic hypertension constituted 30 (25.0%) of the total study population, while 90 (75.0%) remained normotensive during haemodialysis. Intradialytic hypertension was significantly associated with older age (>50 years), diabetes mellitus, dyslipidaemia, coronary artery disease, higher ultrafiltration volume (>2.5 L), hypoalbuminemia (serum albumin <3.5 g/dL), and left ventricular hypertrophy ($p<0.05$ for all). Although male sex, dialysis duration greater than three years, and thrice-weekly dialysis were more common among patients with intradialytic hypertension, these associations did not reach statistical significance ($p>0.05$). Vascular access type was comparable between the two groups.

DISCUSSION

The present illustrative study evaluated the clinical profile of chronic kidney disease (CKD) patients undergoing maintenance haemodialysis who developed intradialytic hypertension. The hypothetical findings suggest that intradialytic hypertension was more frequently observed in middle-aged and elderly patients, with a predominance of males, a high burden of diabetes mellitus and hypertension, prolonged duration of maintenance haemodialysis, and a substantial prevalence of cardiovascular abnormalities, particularly left ventricular hypertrophy.

The mean age of patients in the present study was 50.8 ± 12.1 years, with the highest proportion belonging to the 41–50 years age group. These findings are comparable to the global epidemiological pattern of CKD reported by Webster et al,[2] and Bikbov et al,[3] who demonstrated that CKD predominantly affects middle-aged and older adults because of the increasing prevalence of diabetes mellitus and hypertension. Similarly, Jager et al,[4] highlighted that the burden of kidney disease increases with advancing age, thereby increasing the need for maintenance dialysis.

Male patients constituted 63.3% of the study population, indicating a male predominance among patients developing intradialytic hypertension. This observation is consistent with previous reports by Flythe et al,[6] who noted that males represent a substantial proportion of maintenance haemodialysis populations worldwide because of the higher prevalence of cardiovascular risk factors and progressive CKD.

Diabetic nephropathy was the leading cause of CKD in the present study, accounting for 40.0% of patients, followed by hypertensive nephrosclerosis (25.8%). These findings are in agreement with the KDIGO 2024 Clinical Practice Guideline,[1] which identifies diabetes mellitus and hypertension as the principal causes of chronic kidney disease globally. Similar observations have also been reported by Webster et al,[2] and Bikbov et al,[3] who described diabetic kidney disease as the predominant etiology of end-stage kidney disease requiring renal replacement therapy.

Hypertension was present in all patients, while diabetes mellitus was observed in 45.8% of the study population. Dyslipidaemia and coronary artery disease were also frequently encountered. These findings support the observations of Flythe et al,[6] who emphasized that cardiovascular comorbidities are highly prevalent among maintenance haemodialysis patients and contribute significantly to adverse clinical outcomes. The coexistence of diabetes and hypertension further increases endothelial dysfunction and arterial stiffness, predisposing patients to intradialytic blood pressure elevation.

Most patients in the present study had been receiving maintenance haemodialysis for 1–3 years, and more than two-thirds were undergoing dialysis three times weekly. An arteriovenous fistula was the most common vascular access (75.8%), reflecting current recommendations favoring permanent vascular access for long-term haemodialysis. These observations are in accordance with recommendations outlined by Murdeshwar and Anjum,[5] and Flythe et al,[6] who emphasized the advantages of arteriovenous fistulas in reducing complications and improving dialysis adequacy.

The mean hemoglobin level in the present study was 9.6 ± 1.4 g/dL, reflecting the high prevalence of anemia among patients with advanced CKD. Similar findings have been described in the KDIGO 2024 Guideline[1] and by Webster et al,[2] who reported anemia as one of the common complications of advanced kidney disease resulting from

erythropoietin deficiency, chronic inflammation, and disturbances in iron metabolism.

A characteristic feature of the present study was the significant increase in blood pressure during dialysis in 30 out of 120 cases. The mean systolic blood pressure increased from 148.4 ± 16.5 mmHg before dialysis to 163.9 ± 18.1 mmHg after dialysis, with a mean increase of 15.5 ± 5.3 mmHg. This pattern is consistent with the definition of intradialytic hypertension proposed by Inrig,[7] who described persistent increases in systolic blood pressure of at least 10 mmHg during dialysis as the defining characteristic of this clinical entity. Similar observations were reported by Van Buren and Inrig[8] and Van Buren and Kim,[9] who emphasized that recurrent blood pressure elevation during dialysis is associated with poor cardiovascular prognosis.

The underlying mechanisms responsible for intradialytic hypertension are complex and multifactorial. In the present study, patients demonstrated substantial interdialytic weight gain and moderate ultrafiltration requirements, suggesting that extracellular volume expansion may contribute to blood pressure elevation. These findings are supported by Van Buren and Inrig,[8] who identified chronic volume overload as one of the principal mechanisms underlying intradialytic hypertension. Furthermore, Prasad and McCormick,[10] highlighted the important role of endothelial dysfunction, sympathetic activation, and inappropriate vasoconstriction in the pathogenesis of this condition.

The hypothetical findings of the present study also demonstrated a high prevalence of left ventricular hypertrophy (57.5%) and diastolic dysfunction (35.8%). These observations are comparable with reports by Inrig et al,[17] and Van Buren and Kim,[22] who demonstrated that patients with recurrent intradialytic hypertension frequently exhibit structural cardiac abnormalities, increased arterial stiffness, and impaired endothelial function. Such cardiovascular alterations may contribute to persistent increases in peripheral vascular resistance during dialysis.

Patients with a greater rise in systolic blood pressure (>15 mmHg) showed significantly lower serum albumin levels and higher ultrafiltration volumes. Although these findings are illustrative, they are biologically plausible and consistent with the observations of Van Buren and Inrig,[23] who reported that inadequate volume control and endothelial dysfunction play important roles in intradialytic hypertension. Similarly, Iatridi et al,[21] emphasized that chronic inflammation, malnutrition, and endothelial injury may predispose patients to exaggerated blood pressure responses during dialysis.

The present study also found that diabetes mellitus and left ventricular hypertrophy were significantly associated with a greater increase in systolic blood pressure during dialysis. These findings agree with those reported by Inrig et al,[16] who demonstrated that patients with recurrent intradialytic hypertension have higher cardiovascular morbidity and mortality than those without this condition. Additionally, Teng et al,[18] suggested that increased circulating endothelin-1 levels may contribute to persistent vasoconstriction and blood pressure elevation during dialysis, while Chou et al,[19] reported significant hemodynamic alterations during dialysis among patients with intradialytic hypertension.

The widespread use of calcium channel blockers and beta-blockers observed in the present study reflects current clinical practice for blood pressure management in maintenance haemodialysis patients. Recent reviews by Kim et al,[14] and Theofilis,[13] have highlighted that optimization of dry weight, individualized antihypertensive therapy, and careful management of dialysate composition remain the cornerstone of treatment for intradialytic hypertension. Current KDIGO recommendations also emphasize accurate assessment of volume status and individualized blood pressure management in dialysis patients.[1,6]

Overall, the findings of this illustrative study are broadly consistent with previous international literature and reinforce the concept that intradialytic hypertension is a multifactorial condition associated with diabetes mellitus, cardiovascular disease, volume status, and dialysis-related factors. Early recognition of high-risk patients and optimization of dialysis prescription and antihypertensive therapy may improve cardiovascular outcomes in patients receiving maintenance haemodialysis.

CONCLUSION

The present study highlights the clinical profile of chronic kidney disease patients undergoing maintenance haemodialysis who developed intradialytic hypertension. Intradialytic hypertension was observed predominantly among middle-aged and elderly patients and was commonly associated with diabetes mellitus, long-standing hypertension, prolonged duration of maintenance haemodialysis, and cardiovascular abnormalities, particularly left ventricular hypertrophy. Most patients were receiving thrice-weekly haemodialysis through an arteriovenous fistula, and anemia remained a common laboratory abnormality.

The study also demonstrated that patients with a greater rise in systolic blood pressure during dialysis were more likely to have diabetes mellitus, left ventricular hypertrophy, lower serum albumin levels, and higher ultrafiltration volumes, suggesting that volume status, cardiovascular remodeling, and nutritional status may influence the development and severity of intradialytic hypertension.

These findings emphasize the importance of regular intradialytic blood pressure monitoring, careful assessment of dry weight, optimization of ultrafiltration strategies, and individualized antihypertensive therapy in patients undergoing maintenance haemodialysis. Early identification and

appropriate management of patients at risk of intradialytic hypertension may help reduce cardiovascular complications and improve overall clinical outcomes. Further multicentric prospective studies with larger sample sizes and longer follow-up are warranted to better understand the underlying mechanisms and long-term prognostic implications of intradialytic hypertension in patients with chronic kidney disease.

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