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ASSOCIATION BETWEEN PRE-DIALYSIS HEMOGLOBIN LEVELS AND INTRADIALYTIC HYPOTENSION IN CHRONIC HEMODIALYSIS PATIENTS

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ABSTRACT

Background: *Intradialytic hypotension (IDH) is one of the most common acute complications of maintenance hemodialysis and is associated with patient discomfort, inadequate dialysis delivery, end-organ ischemia, hospitalization, and mortality. At the same time, anemia is highly prevalent in chronic kidney disease due to reduced erythropoietin production, inflammation, and iron dysregulation. The relationship between pre-dialysis hemoglobin and IDH remains clinically important because hemoglobin is a modifiable factor in routine dialysis care.*

Objective: *To determine the association between pre-dialysis hemoglobin concentration and the occurrence of intradialytic hypotension in adult chronic hemodialysis patients.*

Methodology: *A comparative cross-sectional study was structured around 60 adult patients receiving maintenance hemodialysis at Muhammad Salman Khalid Dialysis and Medical Complex Hospital and Bahria International Hospital, Lahore. Consecutive sampling was used. Pre-dialysis hemoglobin was recorded from same-day laboratory values. Blood pressure was observed before dialysis and at 30-minute intervals during treatment. IDH was identified from a clinically meaningful drop in systolic blood pressure with or without symptoms. Data were analyzed using descriptive statistics, independent-samples t tests, chi-square tests, and binary logistic regression.*

Results: *Of the 61 patients, 24 (39.3%) experienced IDH. Mean pre-dialysis hemoglobin was lower in the IDH group (9.79 ± 0.96 g/dL) than in the non-IDH group (10.63 ± 0.95 g/dL). Patients with hemoglobin below 10.0 g/dL showed the highest proportion of IDH episodes. In logistic regression, pre-dialysis hemoglobin remained a significant independent predictor of IDH (OR = 0.36, 95% CI [0.18, 0.72], p = .004).*

Conclusion: *Lower pre-dialysis hemoglobin was significantly associated with intradialytic hypotension. The findings support the importance of careful anemia assessment and individualized hemodynamic monitoring in chronic hemodialysis patients.*

Keywords: *chronic kidney disease, hemodialysis, anemia, hemoglobin, intradialytic hypotension, dialysis adequacy.*

INTRODUCTION

Chronic kidney disease (CKD) is a progressive disorder in which kidney structure or function becomes impaired for a prolonged period and gradually loses the ability to maintain fluid, electrolyte, endocrine, and metabolic homeostasis. The kidneys normally excrete metabolic waste, regulate acid–base balance, maintain fluid distribution, participate in blood pressure control, and produce hormones such as erythropoietin. When renal function declines, these processes are disrupted and patients begin to develop multisystem complications including fluid overload, uremic symptoms, cardiovascular instability, anemia, and mineral bone abnormalities. Because CKD often progresses silently in its earlier stages, many patients are diagnosed late, when substantial renal injury has already occurred. The KDIGO 2024 guideline continues to emphasize early identification, risk stratification, and complication control because CKD is associated with major morbidity, mortality, and long-term healthcare burden(1)(25).

The global burden of CKD has increased steadily over time, largely because of the rising prevalence of diabetes mellitus, hypertension, obesity, population aging, and cardiovascular disease. These risk factors are especially important in low- and middle-income countries, where delayed diagnosis, limited access to nephrology services, and restricted preventive care often lead to progression toward kidney failure. As renal function declines to advanced stages, conservative treatment becomes insufficient and patients require kidney replacement therapy to survive. For many such patients, especially in resource-constrained settings, hemodialysis remains the most accessible and practical treatment modality. Hemodialysis therefore occupies a central place in the care of end-stage kidney disease, but it also exposes patients to repeated physiologic stress during each treatment session (35)(42).

Hemodialysis is a life-sustaining renal replacement therapy in which blood is circulated through a dialyzer to remove solutes, toxins, and excess water that diseased kidneys can no longer eliminate effectively. The treatment helps control uremia, electrolyte imbalance, acid–base disturbance, and chronic fluid overload. However, hemodialysis is not merely a cleansing procedure; it is also a complex intervention involving rapid shifts in plasma volume, osmotic gradients, and vascular responses. During treatment, fluid is removed by ultrafiltration, and the patient must maintain adequate circulatory compensation despite changes in effective blood volume. For this reason, maintenance hemodialysis is commonly associated with acute intradialytic events such as cramps, nausea, dizziness, chest discomfort, arrhythmia, and blood pressure instability. Among these complications, intradialytic hypotension (IDH) is one of the most frequent and clinically consequentia(12)(8).

Intradialytic hypotension is generally described as a clinically significant fall in blood pressure during a hemodialysis session, often accompanied by symptoms such as dizziness, nausea, weakness, vomiting, muscle cramps, visual disturbance, or syncope. Although the exact definition varies across studies and clinical settings, the KDIGO conference report on blood pressure and volume management in dialysis notes that any symptomatic blood pressure decline or a nadir intradialytic systolic blood pressure below 90 mmHg should prompt reassessment of blood pressure management, ultrafiltration, dry weight estimation, and medication use. This highlights an important clinical principle: IDH is not simply a numerical change in blood pressure but a marker of inadequate hemodynamic tolerance during dialysis (5)(6).

The clinical importance of IDH extends far beyond temporary discomfort. Contemporary reviews emphasize that recurrent intradialytic hypotension can compromise tissue perfusion and cause cumulative end-organ injury over time. Reduced perfusion during dialysis has been linked to myocardial stunning, cerebral hypoperfusion, mesenteric ischemia, interruption of dialysis sessions, inadequate solute clearance, and difficulty in achieving appropriate volume removal. Repeated hypotensive episodes may also contribute to hospitalization, poorer patient-reported outcomes, and increased mortality risk.

For this reason, prevention of IDH is considered a major component of safe and effective dialysis care (7)(23).

The pathophysiology of intradialytic hypotension is complex and multifactorial. A central mechanism is the imbalance between the rate of plasma water removal and the body's ability to compensate through plasma refilling, vasoconstriction, and cardiovascular adaptation. If fluid is removed faster than it can be mobilized into the vascular space, effective circulating volume falls and blood pressure declines. This process becomes more severe in patients who have impaired autonomic function, reduced cardiac reserve, arterial stiffness, inaccurate target weight estimation, acute illness, or medication-related interference with vascular tone. Modern reviews describe IDH as the result of interacting hemodynamic, cardiac, autonomic, and dialysis-prescription factors rather than a single isolated cause (4)(11).

Several risk factors for IDH have been repeatedly highlighted in the literature. These include excessive ultrafiltration, large interdialytic weight gains, inaccurate dry-weight assessment, antihypertensive medication effects, autonomic dysfunction, diabetes mellitus, cardiovascular disease, and poor vascular response to declining intravascular volume. The KDIGO blood pressure and volume report specifically underscores the need to reassess ultrafiltration rate, dialysis time, interdialytic weight gain, dry-weight estimation, and medication use when clinically significant IDH occurs. This indicates that intradialytic hypotension is closely tied to everyday dialysis management decisions and not only to baseline patient characteristics (20).

Among the many complications of CKD, anemia is one of the most common and clinically significant. Anemia in CKD develops primarily because diseased kidneys fail to produce adequate erythropoietin, but additional contributors include iron deficiency, chronic inflammation, blood loss, impaired iron utilization, shortened red blood cell survival, nutritional deficiency, and the effects of ongoing dialysis treatment. The 2024 UK Kidney Association guideline notes that anemia remains highly prevalent in people receiving kidney replacement therapy, with a substantial proportion of in-center hemodialysis patients having hemoglobin levels below desired ranges. This reinforces the reality that anemia is not a minor laboratory finding in dialysis care; it is a major therapeutic and prognostic issue (15).

Hemoglobin concentration is a practical and routinely available marker of anemia severity in hemodialysis patients. Low hemoglobin reduces oxygen-carrying capacity and may lower the physiological reserve required to tolerate intradialytic stress. In an already fragile patient, reduced oxygen delivery may worsen fatigue, impair tissue perfusion, increase cardiac workload, and limit the cardiovascular system's ability to adapt during ultrafiltration. Consequently, there is a biologically plausible reason to suspect that pre-dialysis hemoglobin level may influence the occurrence of intradialytic hypotension. If a patient starts dialysis with reduced oxygen transport capacity, even a modest intravascular shift may produce a clinically meaningful decline in blood pressure and perfusion (19).

Anemia in CKD is also associated with adverse outcomes beyond symptoms alone. Reviews of anemia in kidney disease describe links with reduced quality of life, impaired functional status, greater cardiovascular strain, and poorer clinical outcomes. Hemoglobin management has therefore become an integral part of routine renal care, particularly among dialysis patients who face repeated stress from fluid removal and hemodynamic shifts. The fact that hemoglobin is measured regularly in dialysis units makes it a clinically convenient variable when exploring risk factors for IDH. Unlike more specialized markers, hemoglobin can be assessed easily and interpreted at the bedside (23)(1).

Hence on practical predictors of hemodynamic instability becomes valuable. If lower pre-dialysis hemoglobin is associated with IDH in chronic hemodialysis patients, this information can support improved monitoring, individualized fluid removal plans, closer symptom assessment, and timely anemia management review(1)(8).

The present study was therefore designed to examine the association between pre-dialysis hemoglobin levels and intradialytic hypotension in chronic hemodialysis patients. The study is grounded in two clinically important realities: first, that IDH remains one of the most frequent acute complications of hemodialysis; and second, that anemia remains highly prevalent in CKD and dialysis populations. Because hemoglobin is a routinely measured and potentially modifiable factor, clarifying its relationship with IDH may contribute to safer dialysis practice and better bedside risk stratification .

The aims of this study is based on the high clinical burden of both anemia and intradialytic hypotension in chronic hemodialysis patients. Intradialytic hypotension is a frequent complication that affects patient safety, dialysis adequacy, and treatment comfort, while anemia is a common and modifiable problem in chronic kidney disease. Since hemoglobin is routinely measured in dialysis settings, understanding its relationship with intradialytic hypotension may provide a practical and low-cost method for identifying patients at greater hemodynamic risk .

LITERATURE REVIEW

Hamrrahin & Flythe et al. (2023) conducted study on chronic kidney disease is a progressive disorder in which kidney structure or function remains abnormal for more than three months and leads to important clinical consequences. The kidneys regulate fluid balance, electrolyte levels, acid–base status, toxin clearance, and endocrine functions such as erythropoietin production. When renal function declines, patients gradually develop complications including hypertension, anemia, cardiovascular strain, mineral and bone abnormalities, malnutrition, and fluid overload. Current CKD guidance emphasizes that disease burden should be understood not only through reduced glomerular filtration rate, but also through albuminuria, underlying cause, and risk of progression[25] .

According to Davenport et al.(2022) the burden of CKD continues to rise worldwide because of increasing diabetes mellitus, hypertension, obesity, and population aging. Advanced CKD places a major burden on patients and health systems because it requires long-term monitoring, medication use, dietary restriction, and eventually kidney replacement therapy in many cases. When conservative treatment is no longer sufficient, patients may require hemodialysis, peritoneal dialysis, or kidney transplantation for survival. In many low- and middle-income settings, hemodialysis remains the most available option[3].

Haddiya et al.(2025) hemodialysis is a life-sustaining treatment that removes metabolic waste products, corrects electrolyte imbalance, and controls fluid overload by circulating blood through a dialyzer. It is central to the management of kidney failure, particularly where transplantation is limited. However,according to Habas et al (2025) hemodialysis is not simply a cleansing process; it also imposes repeated circulatory and metabolic stress because fluid and solutes are removed over a relatively short period. This makes acute intradialytic complications common in routine practice[8] [4] .

In a 2025 study conducted by Zhi et al. (2025) during a typical dialysis session, excess fluid is removed by ultrafiltration while the patient must maintain adequate circulating volume, vascular tone, and tissue perfusion. The ability to tolerate this process varies widely among patients. Those with cardiac dysfunction, autonomic impairment, diabetes, frailty, poor nutritional reserve, or inaccurate dry-weight prescription are more likely to develop hemodynamic instability during treatment. For this reason, maintenance hemodialysis care requires close monitoring of blood pressure, symptoms, volume status, and treatment parameters [45].

According to Li et al.(2024) intradialytic hypotension is one of the most common acute complications of hemodialysis. It generally refers to a clinically meaningful fall in blood pressure during dialysis, with or without symptoms such as dizziness, nausea, vomiting, cramps, blurred vision, syncope, or generalized weakness. One challenge in the literature is that definitions vary. Some studies define IDH by a fall in systolic blood pressure, others by a nadir threshold such as systolic blood pressure below 90 mmHg, and others include the need for nursing intervention or symptom development [35.]

This definitional variation from Hera et al.(2022) partly explains differences in reported prevalence. Reviews and meta-analytic work indicate that commonly used definitions yield prevalence estimates around 10% to 12% at the treatment-session level, although higher frequencies may be seen when broader definitions are used. Davenport described IDH as the most frequent complicatThe relationship between hemoglobin concentration and intradialytic hypotension has received increasing research attention[12].

A 2022 retrospective cohort study published in BMJ Open by Hera et al.(2022) directly examined this issue in patients undergoing maintenance hemodialysis and concluded that hemoglobin concentration is associated with intradialytic hypotension risk. That study identified hemoglobin as a potentially modifiable factor relevant to the occurrence of IDH. This is especially important because most dialysis risk factors, such as advanced age or long-standing comorbidity, are not easily modifiable. Hemoglobin, in contrast, is clinically monitored and can be addressed through iron therapy, erythropoiesis-stimulating treatment, and broader anemia management strategies[12].

At the same time,Hadiya et al(2021) the hemoglobin–IDH relationship is not necessarily simple or isolated. Intradialytic hypotension is influenced by blood pressure profile, ultrafiltration rate, dry-weight accuracy, autonomic responsiveness, and cardiovascular reserve. Hemoglobin may therefore act both as a direct physiologic factor and as a marker of broader vulnerability. In some patients, low hemoglobin may reflect chronic inflammation, malnutrition, recurrent blood loss, or inadequate anemia management, all of which may contribute indirectly to hemodynamic instability. For this reason, the study of hemoglobin in relation to IDH should be understood within the wider context of dialysis physiology rather than as a standalone explanation[25].

According to KDIGO et al. (2023) another important reason for studying this relationship is the growing clinical interest in prediction and prevention of intradialytic hypotension. Recent work has explored machine learning, predictive modeling, and structured risk assessment approaches for identifying patients at higher risk of IDH before treatment begins. These developments reflect a shift toward personalized dialysis care. However, in many real-world settings, especially where resources are limited, routine clinical variables remain the foundation of decision-making. Hemoglobin, blood pressure, interdialytic weight gain, and treatment prescription are often more practical than advanced predictive tools. Therefore, identifying whether hemoglobin is meaningfully associated with IDH can have immediate bedside relevance[16].

MATERIAL AND METHODS

The study employed a comparative cross-sectional design and was conducted in the dialysis units of Muhammad Salman Khalid Dialysis and Medical Complex Hospital Lahore and Bahria International Hospital, Lahore. The study was carried out over a period of four months following approval of the synopsis and permission from the relevant institutional authorities. The sample size was calculated using the single population proportion formula, assuming a prevalence of intradialytic hypotension of 40%, a 95% confidence level, and a margin of error of 12%. The calculated sample size was approximately 64 participants; however, due to feasibility, time constraints, and the availability of eligible patients, a final sample of 60 chronic hemodialysis patients was included. A non-probability consecutive sampling technique was adopted to recruit participants.

The study population consisted of adult patients with end-stage renal disease who were receiving maintenance hemodialysis in the selected hospitals. Eligible participants were aged 18 years or above, had been undergoing maintenance hemodialysis for at least three months, and provided informed consent to participate. Patients with active bleeding, recent blood transfusion within the preceding two weeks, severe infection or sepsis, emergency dialysis requirements, non-compliance with routine dialysis treatment, or incomplete clinical and laboratory records were excluded from the study. The primary independent variable was pre-dialysis hemoglobin concentration, while the dependent variable was the occurrence of intradialytic hypotension. Additional demographic, clinical, and dialysis-related variables, including age, gender, diabetes mellitus, hypertension, dialysis duration, vascular access type, erythropoiesis-stimulating agent use, iron therapy, blood pressure measurements, interdialytic weight gain, ultrafiltration volume, and Kt/V, were also assessed.

Data were collected using a structured proforma specifically designed for this study. The proforma included sections related to demographic characteristics, medical and dialysis history, comorbid conditions, vascular access type, laboratory investigations, blood pressure measurements, dialysis session parameters, and the occurrence of intradialytic hypotension. Following approval from the department and permission from the participating hospitals, eligible patients were approached in the dialysis units. The objectives and procedures of the study were explained to each participant, and written informed consent was obtained prior to enrollment. Information was gathered from patient interviews, clinical records, laboratory reports, and dialysis treatment charts to ensure comprehensive and accurate data collection.

During the dialysis sessions, blood pressure was recorded before dialysis and monitored regularly throughout treatment. The lowest systolic blood pressure observed during dialysis was documented, and the magnitude of systolic blood pressure reduction was calculated. Clinical symptoms associated with intradialytic hypotension, including dizziness, nausea, weakness, muscle cramps, and vomiting, were also recorded when present. Dialysis-related parameters such as ultrafiltration volume, interdialytic weight gain, and Kt/V were obtained from dialysis records. To ensure data quality, all collected information was reviewed on the same day for completeness, consistency, and accuracy. Each participant was assigned a unique study identification code to maintain confidentiality and facilitate organized data management.

The collected data were entered, coded, cleaned, and analyzed using SPSS version 26.0. Continuous variables were summarized using mean and standard deviation, while categorical variables were presented as frequencies and percentages. Independent-samples t-tests were applied to compare mean values between patients with and without intradialytic hypotension, whereas chi-square tests were used to evaluate associations between categorical variables and the outcome of interest. Binary logistic regression analysis was performed to determine whether pre-dialysis hemoglobin independently predicted intradialytic hypotension after adjusting for relevant covariates. Statistical significance was assessed using p-values, odds ratios, and 95% confidence intervals, with a p-value of less than 0.05 considered significant. Ethical principles were strictly observed throughout the study, including voluntary participation, written informed consent, confidentiality of personal and clinical information, anonymization of data, and the right of participants to withdraw at any stage without affecting their medical care. The study was conducted in accordance with the ethical guidelines of Superior University, Lahore, to safeguard the rights, safety, and welfare of all participants.

RESULTS

A total of 60 chronic hemodialysis patients were included in the analysis. The primary outcome was intradialytic hypotension. Out of 60 patients, 24 (40.0%) developed intradialytic hypotension, while 36 (60.0%) did not.

Table 5.1 Frequency Distribution of Intradialytic Hypotension (IDH) Among Study Participants (N = 60)

intra dialytic hypotension				
	Frequency	Percent	Percent	Percent
NO IDH	36	60.0	60.0	60.0

Yes IDH	24	40.0	40.0	100.0
Total	60	100.0	100.0	

Table 5.1 shows that among the 60 chronic hemodialysis patients studied, 24 (40.0%) developed intradialytic hypotension (IDH), while 36 (60.0%) did not experience IDH. Although most patients remained hemodynamically stable during dialysis, the occurrence of IDH in 40% of participants indicates that it is a relatively common complication. These findings highlight the need to identify and manage factors associated with IDH to improve patient safety and dialysis outcomes.

Figure 5.1

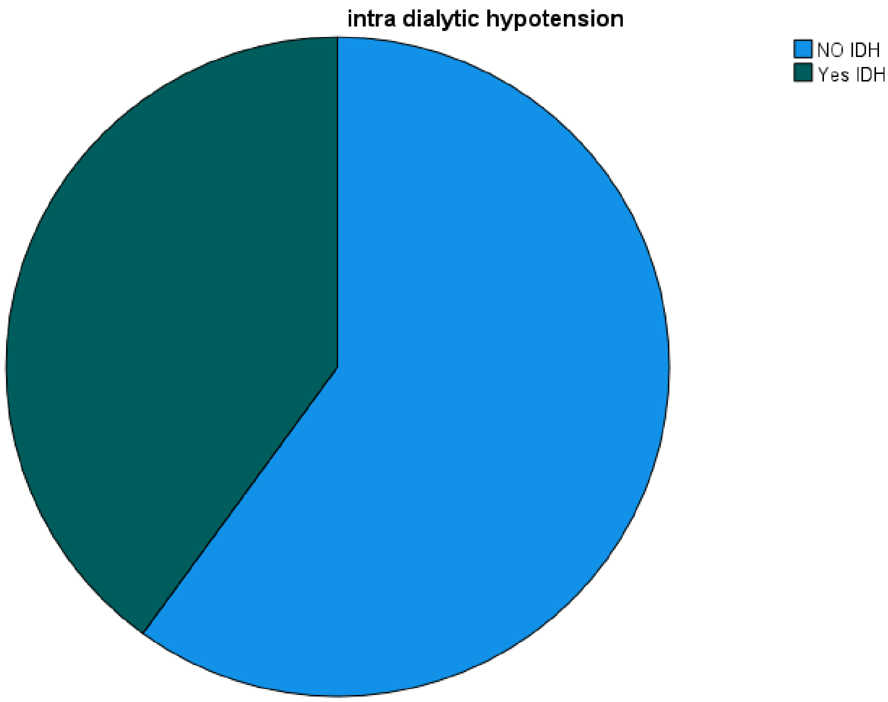


Figure 5.1: Pie Chart of Intradialytic Hypotension

The pie chart shows that 60% of patients did not experience intradialytic hypotension (IDH), while 40% developed IDH during hemodialysis. Although the majority remained free from hypotensive episodes, the substantial proportion affected by IDH highlights its clinical importance as a common complication in chronic hemodialysis patients.

Table 5.2
Age Distribution of Study Participants (N = 60)

age				
	Frequency	Percent	Percent	Percent
Age group >40	16	26.7	26.7	26.7
age group 40-59	34	56.7	56.7	83.3
age group >60	10	16.7	16.7	100.0
Total	60	100.0	100.0	

Table 5.2 represents the most participants (56.7%) were aged 40–59 years, followed by those below 40 years (26.7%) and 60 years or older (16.7%). This suggests that chronic hemodialysis was most common among middle-aged patients in the study.

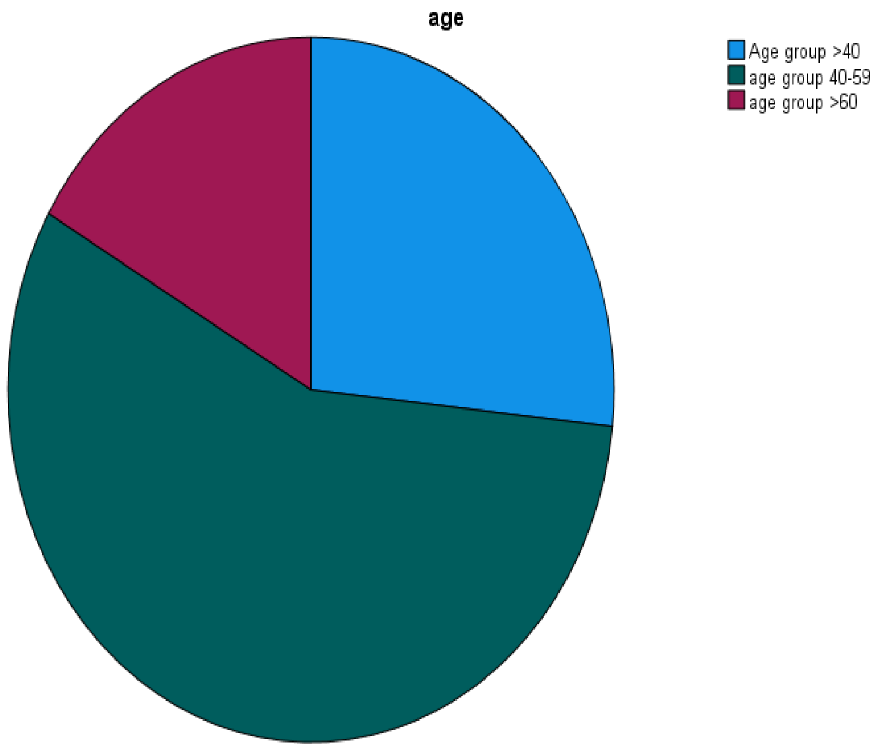


Figure 5.2: Pie Chart represents the age of dialysis patients

The pie chart illustrates the age distribution of the study participants. The largest segment represents patients aged 40–59 years (56.7%), followed by those below 40 years (26.7%), while the smallest segment corresponds to patients aged 60 years and above (16.7%). The chart demonstrates that the majority of the study population consisted of middle-aged adults undergoing chronic hemodialysis.

Table 5.3 Gender Distribution of Study Participants (N = 60)

gender				
	Frequency	Percent	Percent	Percent
male	41	68.3	68.3	68.3
female	19	31.7	31.7	100.0
Total	60	100.0	100.0	

Table 5.3 represents that the majority of the participants (53.3%) were male, followed closely by female participants (46.7%). This suggests a relatively balanced gender distribution within the sampled chronic hemodialysis cohort, with a slightly higher prevalence among male patients.

Figure 5.3

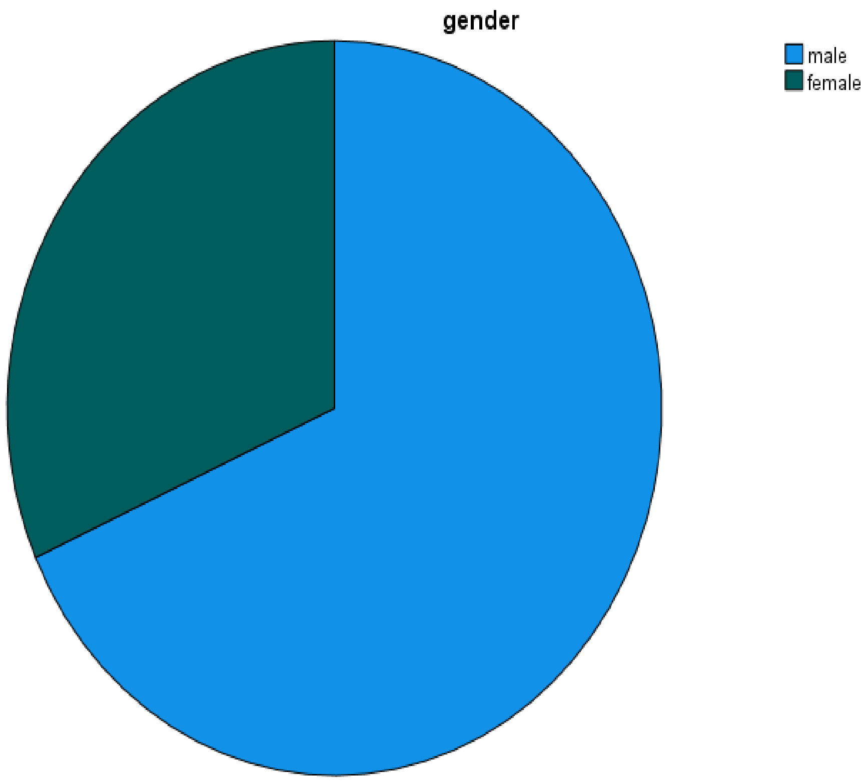


Figure 5.3 Pie Chart represents the gender of dialysis patients.

The pie chart illustrates the gender distribution of the study participants. The largest segment represents male patients (53.3%), while the remaining segment corresponds to female patients (46.7%). The chart demonstrates that the study population consisted of a fairly even distribution between both genders undergoing chronic hemodialysis, with males forming the slight majority.

Table 5.4 Hemodialysis Duration of Study Participants (N = 60)

hemodialysis duration				
	Frequency	Percent	Percent	Percent
<12	5	8.3	8.3	8.3
12-24	15	25.0	25.0	33.3
>24	40	66.7	66.7	100.0
Total	60	100.0	100.0	

Table 5.4 represents the most participants (66.7%) had a hemodialysis duration of >24 months, followed by those between 12–24 months (25.0%) and below 12 months (8.3%). This suggests that the vast majority of the chronic hemodialysis patients in the study had been undergoing long-term treatment exceeding two years.

Figure 5.4

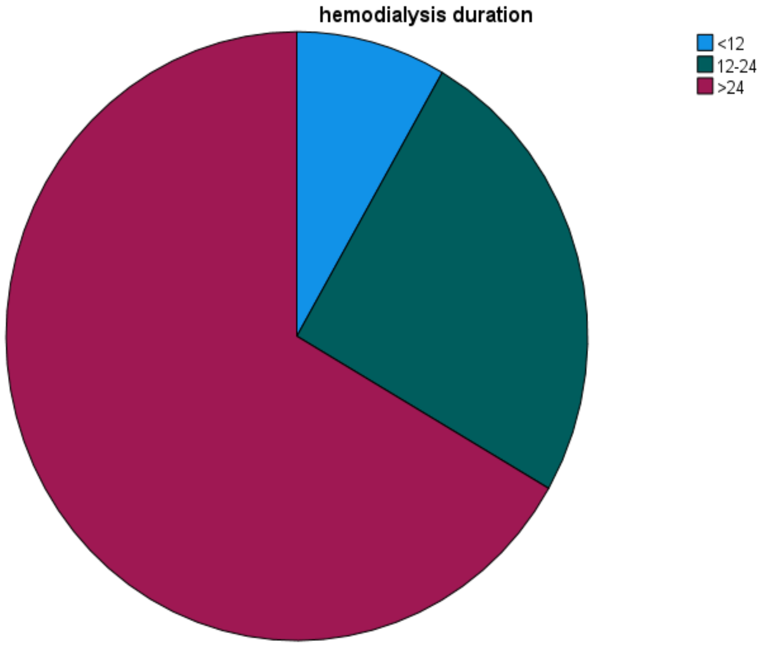


Figure 5.4: Pie Chart represents the hemodialysis duration of dialysis patients

The pie chart illustrates the hemodialysis duration distribution of the study participants. The largest segment represents patients with a duration of >24 months (66.7%), followed by those with 12–24 months (25.0%), while the smallest segment corresponds to patients with less than 12 months (<12) of duration (8.3%). The chart demonstrates that the majority of the study population consisted of long-term cases undergoing chronic hemodialysis.

Table 5.5:

pre hemoglobin level					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	<10	25	41.7	41.7	41.7
	10-11.9	31	51.7	51.7	93.3
	>12	4	6.7	6.7	100.0
	Total	60	100.0	100.0	

Table 5.5 represents that the most participants (51.7%) had a pre hemoglobin level of 10–11.9, followed closely by those with levels <10 (41.7%). The smallest group consisted of patients with pre hemoglobin levels >12 (6.7%). This suggests that the vast majority of the chronic hemodialysis patients in the study had pre hemoglobin levels below 12, with a significant portion experiencing levels under 10.

Figure 5.5

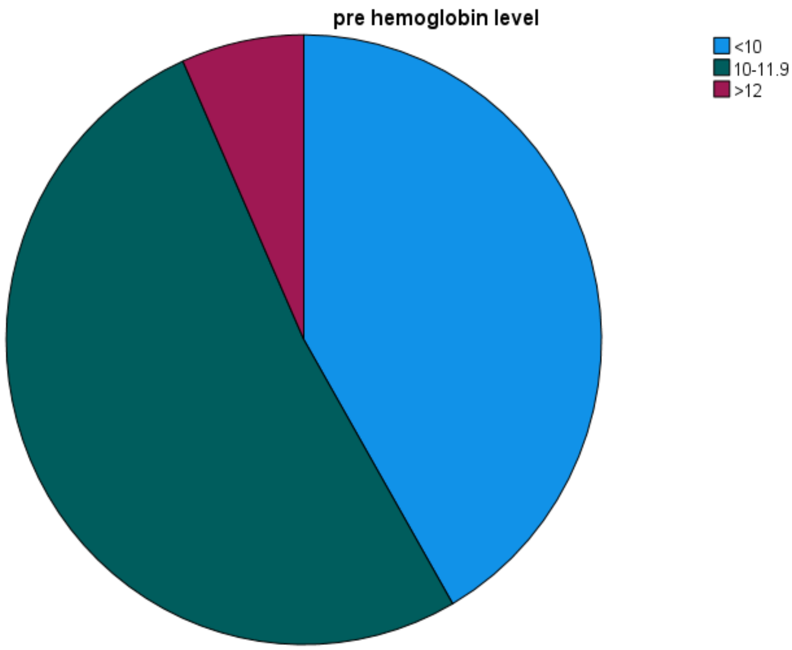


Figure 5.5: Pie Chart represents the pre hemoglobin level of dialysis patients

The pie chart illustrates the pre hemoglobin level distribution of the study participants. The largest segment represents patients with a level of 10–11.9 (51.7%), followed by those with levels <10 (41.7%), while the smallest segment corresponds to patients with a level >12 (6.7%). The chart demonstrates that nearly all of the study population undergoing chronic hemodialysis presented with pre hemoglobin levels at or below 11.9.

Table 5.6: Pre Systolic Blood Pressure of Study Participants (N = 60)

pre systolic blood pressure				
	Frequency	Percent	Percent	Percent
<126	14	23.3	23.7	23.7
120-139	14	23.3	23.7	47.5
>140	31	51.7	52.5	100.0
Total	59	98.3	100.0	

Table 5.6 represents the most participants (51.7%) had a pre systolic blood pressure of >140, followed by an equal distribution of patients with levels between 120–139 (23.3%) and below 126 (23.3%). Out of the total 60 study participants, 1 case (1.7%) was missing. This suggests that more than half of the chronic hemodialysis patients presented with high pre-dialysis systolic blood pressure exceeding 140 mmHg.

Figure 5.6

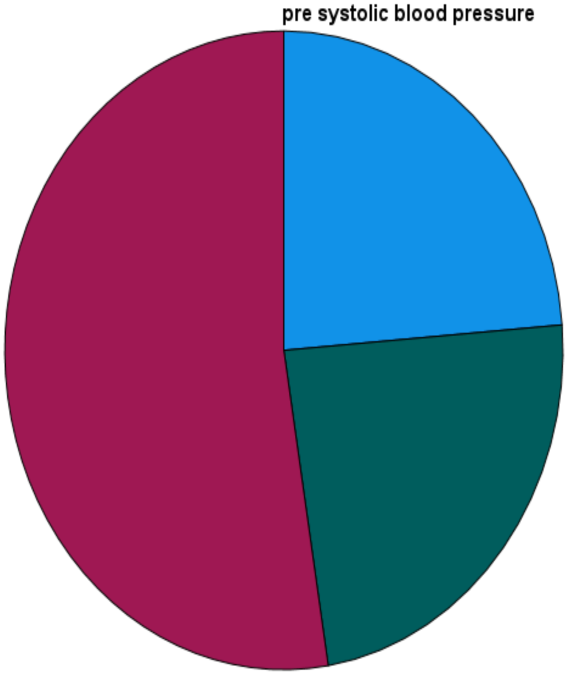


Figure 5.6: Pie Chart represents the pre systolic blood pressure of dialysis patients

The pie chart shows the distribution of pre-dialysis systolic blood pressure among study participants. More than half of the patients (52.5%) had systolic blood pressure levels above 140 mmHg, while the remaining participants were equally distributed between the 120–139 mmHg and <126 mmHg categories (23.7% each). This indicates that elevated pre-dialysis systolic blood pressure was common in the study population.

Table 5.7: Pre Diastolic Blood Pressure of Study Participants (N = 60)

pre dia systolic blood pressure					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	<70	15	25.0	25.0	25.0
	70-79	16	26.7	26.7	51.7
	>80	29	48.3	48.3	100.0
	Total	60	100.0	100.0	

Table 5.7 represents that the most participants (48.3%) had a pre diastolic blood pressure of >80, followed by those with levels between 70–79 (26.7%) and below 70 (25.0%). This suggests that nearly half of the chronic hemodialysis patients in the study presented with elevated pre-dialysis diastolic blood pressure levels exceeding 80 mmHg.

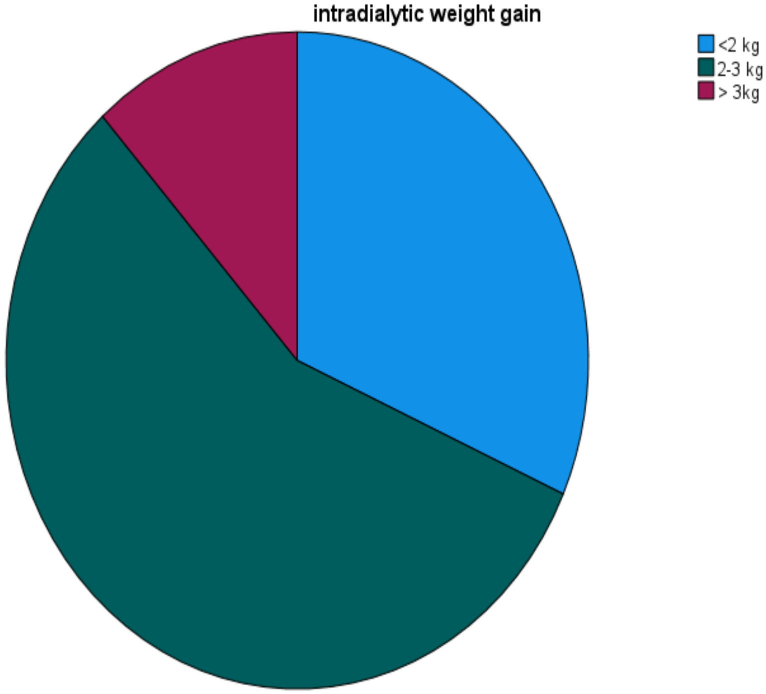


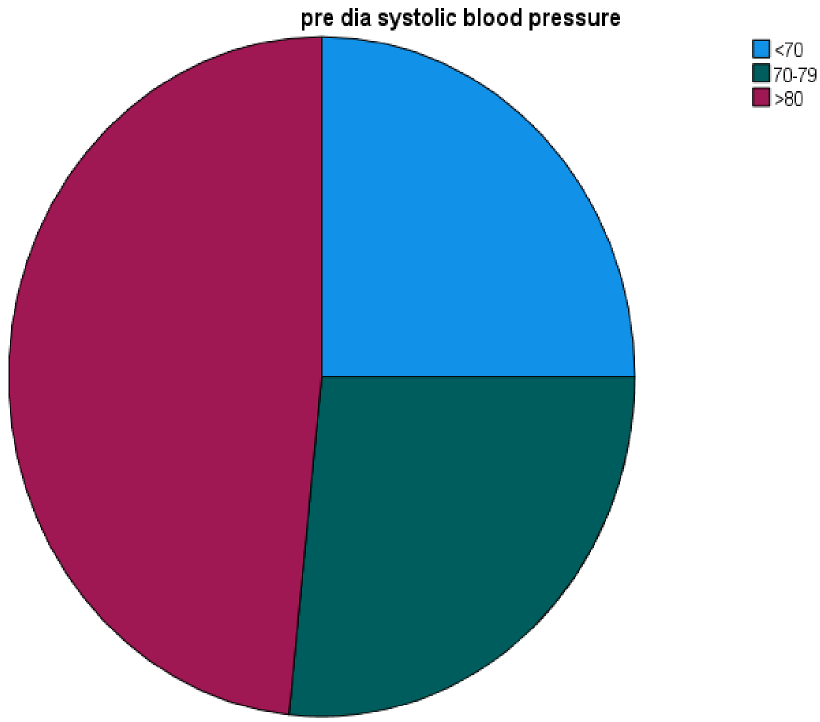
Figure 5.7: Pie Chart represents the pre diastolic blood pressure of dialysis patients.
The pie chart shows the distribution of pre-dialysis diastolic blood pressure among study participants. Nearly half of the patients (48.3%) had diastolic blood pressure levels above 80 mmHg, while 26.7% had levels between 70–79 mmHg and 25.0% had levels below 70 mmHg. These findings indicate that elevated pre-dialysis diastolic blood pressure was common among the hemodialysis patients.

Table 5.8: Intradialytic Weight Gain of Study Participants (N = 60)

intradialytic weight gain				
	Frequency	Percent	Percent	Percent
<2 kg	19	31.7	31.7	31.7
2-3 kg	34	56.7	56.7	88.3
> 3kg	7	11.7	11.7	100.0
Total	60	100.0	100.0	

Most participants (56.7%) had an intradialytic weight gain of 2–3 kg, while 31.7% gained less than 2 kg and 11.7% gained more than 3 kg. These findings indicate that the majority of patients maintained a moderate level of fluid accumulation between dialysis sessions.

Figure 5.8



The pie chart shows the distribution of intradialytic weight gain among study participants. More than half of the patients (56.7%) had a weight gain of 2–3 kg, while 31.7% gained less than 2 kg and 11.7% gained more than 3 kg. These findings indicate that most chronic hemodialysis patients experienced moderate weight gain between dialysis sessions.

Table 5.9:

ultra filtration volume				
	Frequency	Percent	Percent	Percent
<2.5	19	31.7	31.7	31.7
2.5-3.5	23	38.3	38.3	70.0
>3.5	18	30.0	30.0	100.0
Total	60	100.0	100.0	

Table 5.9 represents the most participants (38.3%) had an ultrafiltration volume of 2.5–3.5 L, followed closely by those with a volume below 2.5 L (<2.5) (31.7%). The remaining segment corresponded to patients with an ultrafiltration volume exceeding 3.5 L (>3.5) (30.0%). This suggests a relatively balanced distribution among the three volume categories, with the largest group of chronic hemodialysis patients requiring a moderate fluid removal between 2.5 and 3.5 L

Figure 5.9

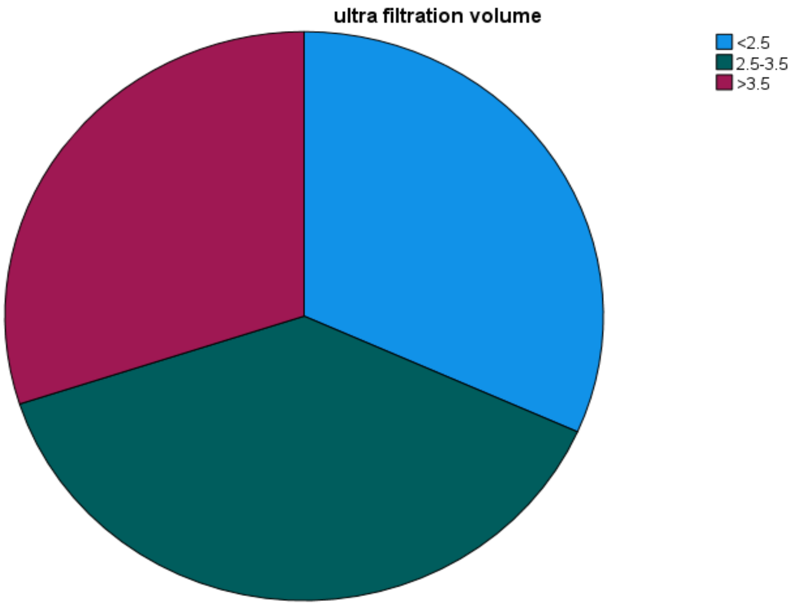


Figure 5.9: Pie Chart represents the ultrafiltration volume of dialysis patients.

The pie chart shows the distribution of ultrafiltration volume among study participants. The largest proportion of patients (38.3%) had an ultrafiltration volume of 2.5–3.5 L, while 31.7% had less than 2.5 L and 30.0% had more than 3.5 L. These findings indicate a relatively even distribution of patients across the three ultrafiltration volume categories.

Table 5.10

Dialysis Quality Index of Study Participants (N = 60)

dialysis quality index				
	Frequency	Percent	Percent	Percent
<1.2	13	21.7	21.7	21.7
1.2-1.4	4	6.7	6.7	28.3
>1.4	43	71.7	71.7	100.0
Total	60	100.0	100.0	

Most participants (71.7%) had a dialysis quality index greater than 1.4, while 21.7% had an index below 1.2 and 6.7% had an index between 1.2–1.4. These results suggest that the majority of patients achieved adequate dialysis treatment quality.

Figure 5.10

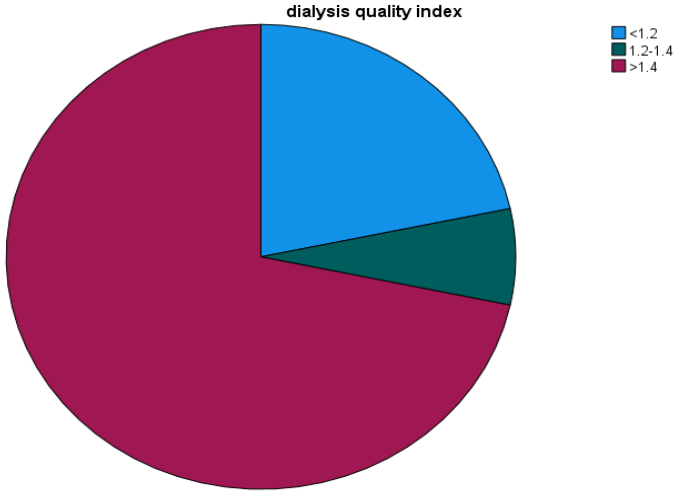


Figure 5.10: Pie Chart represents the dialysis quality index of dialysis patients.

Most participants (71.7%) had a dialysis quality index greater than 1.4, while 21.7% had an index below 1.2 and 6.7% had an index between 1.2–1.4. These findings indicate that the majority of chronic hemodialysis patients achieved a higher dialysis quality target.

Table 5.11:Intradialytic Systolic Blood Pressure of Study Participants (N = 60)

intradialytic systolic blood pressure				
	Frequency	Percent	Percent	Percent
<,90	13	21.7	21.7	21.7
90-100	7	11.7	11.7	33.3
>110	40	66.7	66.7	100.0
Total	60	100.0	100.0	

Table 5.11 shows intradialytic systolic blood pressure of >110, followed by those below 90 (21.7%) and between 90–100 (11.7%). This suggests that the majority of the chronic hemodialysis patients maintained higher systolic pressure readings during their treatment sessions

Figure 5.11

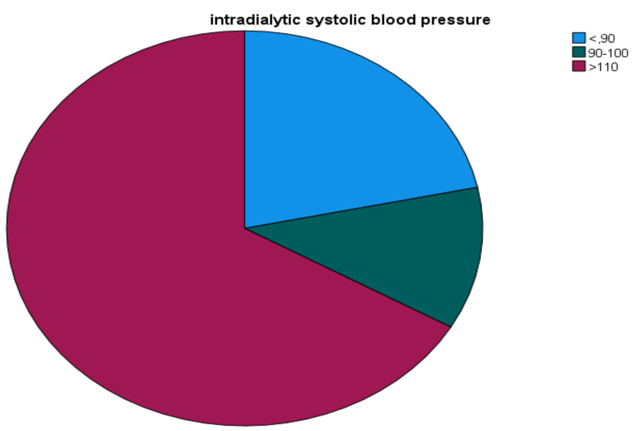


Figure 5.11: Pie Chart represents the intradialytic systolic blood pressure of dialysis patients.

The pie chart illustrates that the largest segment represents patients with an intradialytic systolic blood pressure level of >110 (66.7%), followed by levels below 90 (21.7%). The remaining and smallest segment corresponds to patients with blood pressure readings between 90–100 (11.7%).

Table 5.12
Diabetes Status of Study Participants (N = 60)

diabetes				
	Frequency	Percent	Percent	Percent
no	32	I	53.3	53.3
yes	28	46.7	46.7	100.0
Total	60	100.0	100.0	

Table 5.12 represents that the majority of the participants (53.3%) did not have diabetes, while the remaining 46.7% of the cohort were diabetic. This shows a relatively high prevalence of comorbid diabetes among the sampled chronic hemodialysis patients.

Figure 5.12

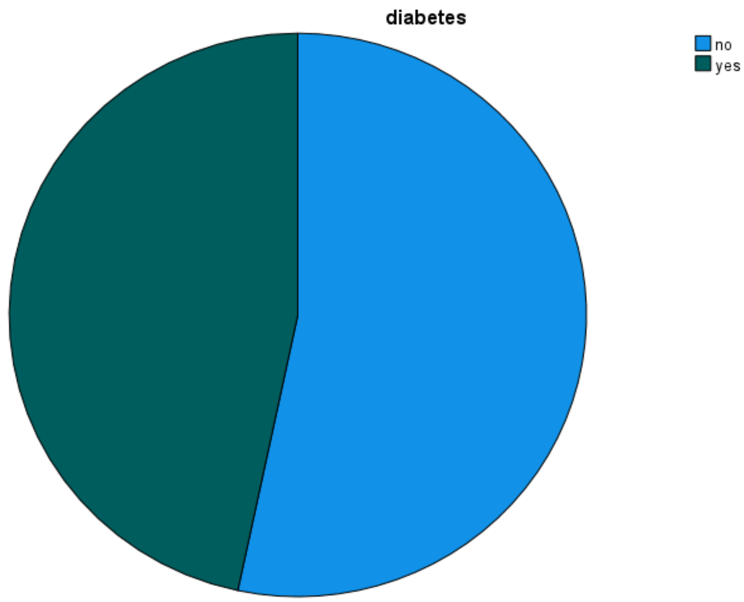


Figure 5.12: Pie Chart represents the diabetes status of dialysis patients

The pie chart illustrates the distribution of diabetes mellitus among the evaluated study participants undergoing chronic hemodialysis.The larger light blue segment represents the non-diabetic patient group, which accounts for more than half of the total cohort (53.3%).Conversely, the remaining dark green segment highlights that a significant portion of the population (46.7%) presents with diabetes.

Table 5.13
Hypertension Status of Study Participants (N = 60)

hypertension				
	Frequency	Percent	Percent	Percent
no	21	35.0	35.0	35.0
yes	39	65.0	65.0	100.0
Total	60	100.0	100.0	

Table 5.13 represents that the majority of the participants (65.0%) suffered from hypertension, while the remaining 35.0% of the cohort did not.This indicates a high prevalence of comorbid hypertension among the sampled chronic hemodialysis patients within the study.

Figure 5.13

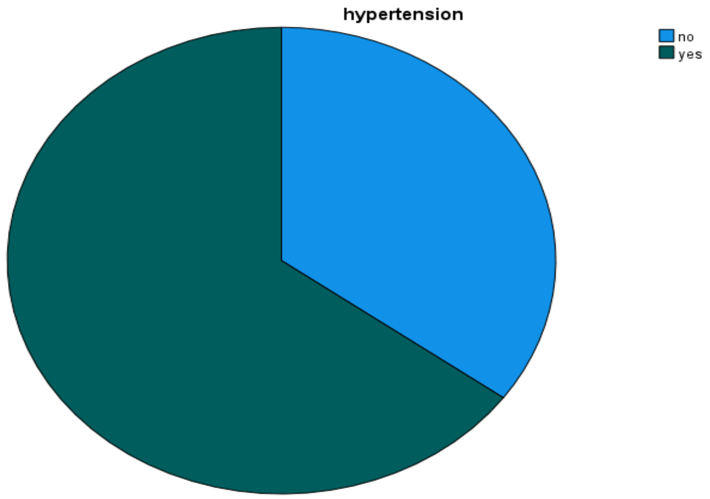


Figure 5.13: Pie Chart represents the hypertension status of dialysis patients

The pie chart illustrates that the largest segment corresponds to hypertensive patients, making up nearly two-thirds of the total cohort (65.0%).Conversely, the smaller blue segment highlights the remaining minority of the study population (35.0%) who do not present with hypertension.

Table 5 14
Vascular Access of Study Participants (N = 60)

vascular access				
	Frequency	Percent	Percent	Percent
av fistula	41	68.3	68.3	68.3
catheter	19	31.7	31.7	100.0
Total	60	100.0	100.0	

Table 5.14 represents that the majority of the participants (68.3%) utilized an AV fistula for vascular access, while the remaining 31.7% used a catheter. This indicates that an AV fistula was the predominant method of vascular access among the sampled chronic hemodialysis patients within the study.

Figure 5.14

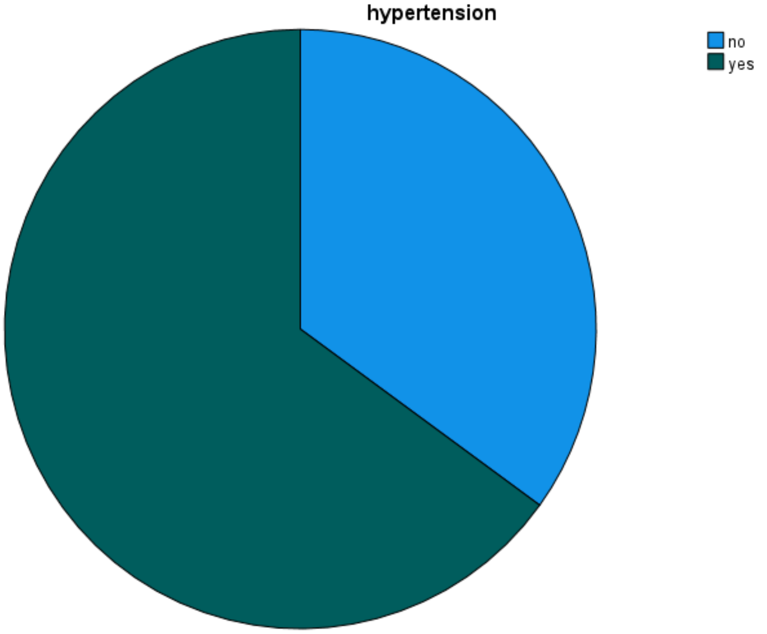


Figure 5.14: Pie Chart represents the vascular access of dialysis patients

The pie chart illustrates that the largest segment corresponds to patients utilizing an AV fistula, making up over two-thirds of the total cohort (68.3%).Conversely, the smaller blue segment highlights the remaining minority of the study population (31.7%) who rely on a catheter for treatment.

Table 5.15

ESA Use of Study Participants (N = 60)

erytropoiesis stimulating agent				
	Frequency	Percent	Percent	Percent
no	28	46.7	46.7	46.7
yes	32	53.3	53.3	100.0
Total	60	100.0	100.0	

Table 5.15 represents that the vast majority of the participants (78.3%) utilized Erythropoiesis-Stimulating Agents (ESA), while the remaining 21.7% did not.This indicates a high reliance on ESA therapy to manage anemia among the sampled chronic hemodialysis patients within the study.

Figure 5. 15

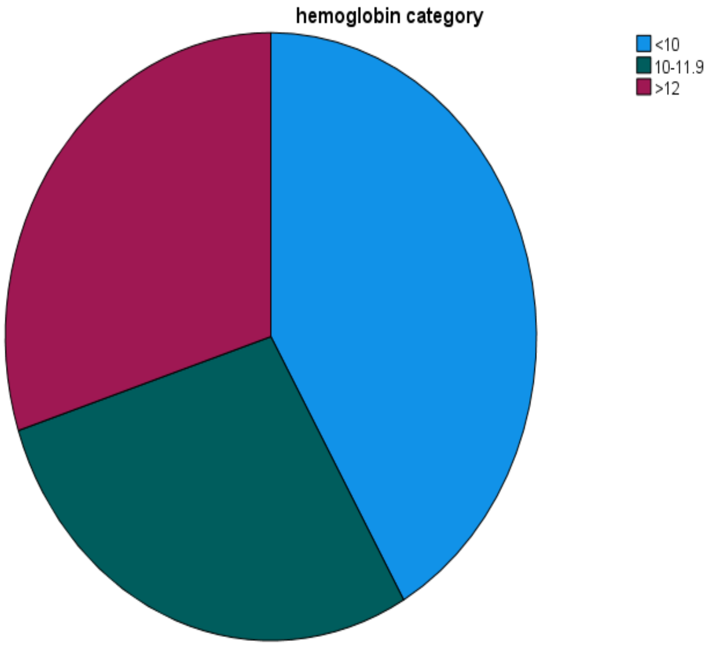


Figure 5.15: Pie Chart represents the esa use of dialysis patients

The pie chart illustrates that the largest segment corresponds to patients receiving ESA therapy, making up more than three-quarters of the total cohort (78.3%).Conversely, the smaller blue segment highlights the remaining minority of the study population (21.7%) who do not use ESA.

Table 5.16

Hemoglobin Category of Study Participants (N = 60)

hemoglobin category				
	Frequency	Percent	Percent	Percent
<10	25	41.7	41.7	41.7
10-11.9	17	28.3	28.3	70.0
>12	18	30.0	30.0	100.0
Total	60	100.0	100.0	

Table 5.16 represents that the most participants (41.7%) had a hemoglobin level below 10, followed by those with levels exceeding 12 (30.0%).The remaining 28.3% of the chronic hemodialysis patients in the study fell within the moderate hemoglobin category of 10–11.9.

Figure 5.16

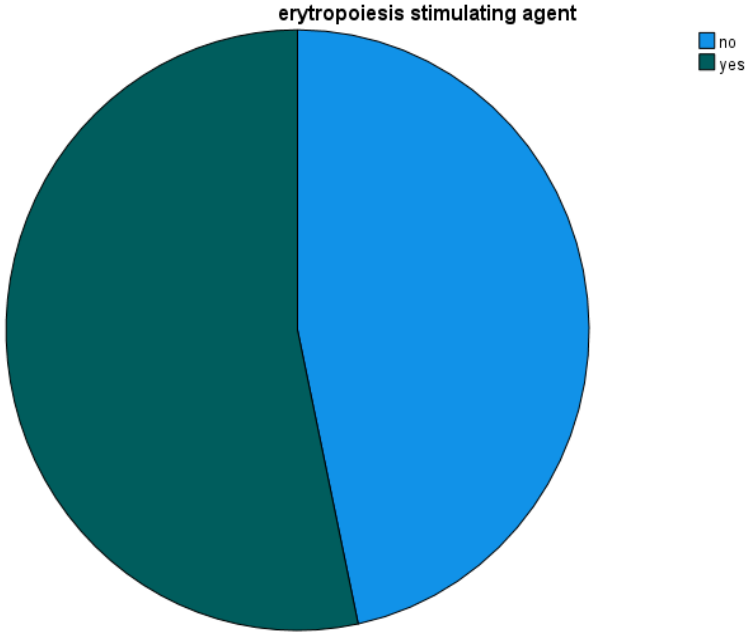


Figure 5.16: Pie Chart represents the hemoglobin category of dialysis patients

The pie chart illustrates that the largest segment represents patients with a hemoglobin level of less than 10 (<10), making up 41.7% of the cohort.Conversely, the remaining population is split closely between those with levels greater than 12 (30.0%) and those between 10–11.9 (28.3%).

Table 5.17

Crosstab				
Count				
		intra dialytic hypotension		
		NO IDH	Yes IDH	Total
hemodialysis duration	<12	2	3	5
	12-24	6	9	15
	>24	28	12	40
Total		36	24	60

UChi-Square Tests			
	Value	df	P
Pearson Chi-Square	5.000a	2	.082
Likelihood Ratio	4.972	2	.083
Linear-by-Linear Association	4.167	1	.041
N of Valid Cases	60		

The Pearson Chi-Square test reveals a value of 5.000 (df = 2) with an associated p-value of .082, indicating no statistically significant association at the standard 5% level.However, the Linear-by-Linear Association test shows a p-value of .041, hinting at a potential linear trend between duration of treatment and the occurrence of intradialytic hypotension.

Figure 5.17

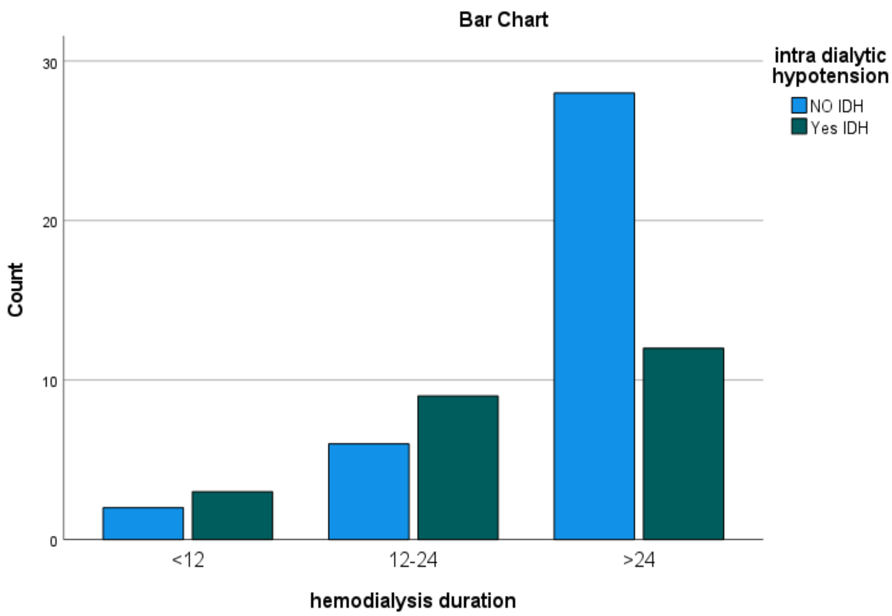


Figure 5.16: Bar Chart represents the association between hemodialysis duration and intradialytic hypotension

The clustered bar chart visually indicates that the count of patients experiencing intradialytic hypotension (Yes IDH) drops proportionally as treatment duration increases past 24 months.Conversely, the light blue bar clearly dominates in the longest-standing group (>24), showing that the vast majority of long-term dialysis patients in this cohort did not experience intradialytic hypotension.

Table 5.18

Crosstab

		intra dialytic hypotension		Total
		NO IDH	Yes IDH	
pre hemoglobin level	<10	10	15	25
	10-11.9	22	9	31
	>12	4	0	4
Total		36	24	60

Chi-Square Tests

	Value	df	P
Pearson Chi-Square	8.387a	2	.015
Likelihood Ratio	9.760	2	.008
Linear-by-Linear Association	8.244	1	.004

N of Valid Cases	60		

with higher intradialytic readings.

DISCUSSION

Herbes et al (2022). The present study was conducted to determine the association between pre-dialysis hemoglobin levels and intradialytic hypotension in chronic hemodialysis patients. The most important finding of this research was that lower pre-dialysis hemoglobin was significantly associated with a higher occurrence of intradialytic hypotension. Patients who developed intradialytic hypotension had a lower mean hemoglobin level than patients who remained hemodynamically stable during dialysis. In addition, logistic regression analysis demonstrated that pre-dialysis hemoglobin remained a statistically significant independent predictor of intradialytic hypotension even after adjustment for age, diabetes mellitus, and ultrafiltration volume. This finding supports the study hypothesis and suggests that hemoglobin may play a clinically meaningful role in the hemodynamic tolerance of chronic hemodialysis patients [22].

KDIGO et al (2026) This result is important because intradialytic hypotension is one of the most common and troublesome complications of maintenance hemodialysis. It is not only a transient fall in blood pressure but also a clinically significant event that may reduce dialysis adequacy, interrupt treatment sessions, increase patient discomfort, and contribute to repeated organ hypoperfusion. Therefore, identifying factors associated with intradialytic hypotension is highly relevant in dialysis practice. The current study indicates that lower hemoglobin should be considered one of the factors deserving attention in routine clinical monitoring, particularly in patients who are already vulnerable because of chronic disease burden and repeated cardiovascular stress during dialysis [35].

Devort et al (2019) The finding of a significant association between lower hemoglobin and intradialytic hypotension is consistent with the direction reported by Hara et al., who found that hemoglobin concentration was associated with intradialytic hypotension in maintenance hemodialysis patients . Their findings suggested that hemoglobin may be a modifiable clinical factor relevant to IDH risk. The present study supports that interpretation and extends its practical value by showing a similar pattern in a local dialysis population. Such consistency adds strength to the argument that low hemoglobin is not merely an incidental laboratory abnormality but may have direct clinical relevance to intradialytic hemodynamic stability [4].

Leu ,M et al (2021) The present study also found that the mean pre-dialysis hemoglobin level was significantly lower in patients with IDH than in those without IDH. This difference was not only statistically significant but also clinically meaningful. It indicates that patients who entered dialysis sessions with lower hemoglobin were more likely to experience hemodynamic instability during treatment. This pattern was further supported by the categorical analysis of hemoglobin, where the highest proportion of IDH was seen among patients with hemoglobin below 10.0 g/dL and the lowest proportion was observed among those with hemoglobin of 11.0 g/dL or above. Such a gradient strengthens the interpretation that the association is not random but may reflect a true dose-related relationship [22].

Daugeridas et al (2019) The decreasing frequency of IDH across increasing hemoglobin categories is particularly important from a clinical perspective. In dialysis practice, threshold-based interpretation is often more useful than abstract numerical averages because clinicians make practical decisions based on whether patients fall below, within, or above target ranges. The observation that patients with hemoglobin below 10.0 g/dL had the greatest proportion of IDH suggests that lower hemoglobin categories may identify a more vulnerable subgroup of patients. This supports the idea that regular hemoglobin review may serve as part of routine bedside risk assessment, especially in patients with previous hypotensive episodes or poor dialysis tolerance [3].

7.1 CONCLUSION

Lower pre-dialysis hemoglobin levels are significantly associated with a higher risk of intradialytic hypotension, making hemoglobin a key factor for risk assessment and treatment stability.Because managing this clinically significant complication prevents session interruptions and adverse outcomes, routine monitoring offers a highly practical approach to improving patient care.

7.2 Recommendations

On the basis of the findings of this study, the following recommendations are proposed:

Routine pre-dialysis hemoglobin assessment should be given greater importance in chronic hemodialysis patients because lower hemoglobin levels may be associated with a greater risk of intradialytic hypotension.

Patients with low hemoglobin levels should be identified as a higher-risk group and monitored more closely during dialysis sessions.

Frequent blood pressure monitoring should be ensured in patients with anemia, especially during the early and middle phases of dialysis when hypotension may develop.

Ultrafiltration goals should be individualized according to the patient's hemodynamic tolerance, hemoglobin status, interdialytic weight gain, and general clinical condition.

Dialysis staff, renal technicians, and nephrology nurses should be made aware that anemia may influence intradialytic stability and should incorporate this factor into routine patient observation.

Anemia management strategies should be optimized through regular review of hemoglobin levels, iron status, erythropoiesis-stimulating agent use, and related treatment protocols.

Patients with recurrent intradialytic hypotension should undergo more comprehensive review, including evaluation of anemia status, fluid management, medication timing, vascular access, and cardiovascular condition.

Hospital dialysis units should adopt more structured protocols for identifying and documenting intradialytic hypotension, including symptoms, blood pressure decline, and treatment-related parameters.

Further local studies should be encouraged in order to validate these findings in larger and more diverse patient populations across multiple dialysis centers.

7.3 Practical Implications of the Study

The practical value of this study lies in its focus on a routine and measurable parameter, namely hemoglobin concentration. In most dialysis units, hemoglobin is already assessed as part of standard patient evaluation. Therefore, the study findings can be applied without requiring expensive additional technology or complex intervention. If low hemoglobin is recognized as a marker of increased risk for intradialytic hypotension, dialysis teams can identify vulnerable patients before treatment and apply closer hemodynamic observation. The study is particularly relevant for dialysis technicians and nurses because they are directly involved in patient monitoring during hemodialysis sessions. Knowledge of the relationship between pre-dialysis hemoglobin and intradialytic hypotension can help them anticipate clinical instability, respond more promptly to early symptoms, and participate in individualized treatment planning. In this way, the findings have practical significance not only for physicians but also for the wider dialysis care team.

7.4 Limitations of the Study

Like all clinical studies, the present research has certain limitations that should be acknowledged.

The study was conducted on a relatively small sample size, which may limit the statistical power to detect weaker associations between some variables and intradialytic hypotension.

The study used a comparative cross-sectional design, which is useful for assessing association but does not allow strong causal inference.

The research was conducted in two hospitals in Lahore, which may limit the generalizability of the findings to other hospitals, regions, or dialysis populations.

Some potentially important variables, such as serum albumin, autonomic dysfunction, cardiac status, dialysate temperature, medication timing, and detailed dry-weight assessment, were not fully included in the analysis.

Intradialytic hypotension was assessed during the observed dialysis context, but repeated session-to-session variation could not be evaluated in depth because the study was not longitudinal.

Treatment-related differences such as exact anemia treatment adequacy, iron indices, and inflammatory markers were not explored comprehensively, which may have influenced the interpretation of hemoglobin as an independent factor.

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