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STATUS OF DELIVERED DOSE OF HEMODIALYSIS IN SAMPLE OF IRAQI PATIENTS

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Abstract
Background: Chronic kidney disease (CKD) has been and continues to be one of the leading causes of death and morbidity worldwide. Dialysis is considered one of the most important methods in the treatment of chronic kidney disease, and the issue of the ideal dose and frequency of dialysis has been at the forefront of important topics in dialysis treatment. Therefore, it may be possible to reduce morbidity and mortality by regularly assessing the dialysis dose provided to patients.
Aim of study: to evaluate the delivered dose of dialysis among patients with chronic kidney disease in Iraq.
Methods: A cross-sectional descriptive study was conducted at the single dialysis center in the Medical City Complex in Baghdad from April 1, 2024, until the end of October. All patients diagnosed with end-stage renal failure who were undergoing regular dialysis from both genders (males and females) during the study period were registered and selected according to specific criteria after consenting to participate in the study. The dialysis dose was measured through an online clearance monitoring device simultaneously and utilizing a structured questionnaire to collect information from participants by converting the data into a computerized database structure utilizing SPSS software version 26.
Results: The total sample was 100 patients. 44% of them were male and 56% female, with mean age of 51.5 years. Only 58% of the participants had a low dose (Kt/v). The findings illustrated that 69% of the participants with a low (Kt/v) magnitude were females, patients with double catheters, those with a normal or low body mass index, as well as those with shorter dialysis periods with statistical significance. Also, most of the participants who had a low (Kt/v) were among those who suffered from chronic diseases and had QP and Qd mean below the normal range.
Conclusion: more than half of participants had low delivered dose with statically significant association with gender ,duration of dialysis , BMI, chronic disease and dialysis flow.
Keywords: Hemodialysis Dose, Chronic Kidney Disease, Dialysis Adequacy, End-Stage Renal Disease, Patient-Specific Factors.

1. Introduction

The human renal system plays a critical role in maintaining homeostasis by regulating blood composition, removing metabolic waste products like urea, uric acid, and creatinine, and excreting them via urine [1]. Kidneys, bean-shaped organs located retroperitoneally in the posterior abdominal wall on either side of the spine at the level of the upper lumbar vertebrae, perform these essential functions [2]. Each kidney contains a renal parenchyma, divided into a

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cortex and medulla, which houses the nephrons, the structural and functional units of the kidney [1,3]. Nephrons consist of a glomerulus and a tubule. The glomerulus, a network of capillaries, filters blood as it enters Bowman's capsule via the afferent arteriole under high pressure [4,5]. Filtered blood exits the glomerulus through the efferent arteriole, also at high pressure [6,7]. Following filtration, the filtrate progresses through the proximal tubule, which consists of convoluted and straight sections, descends through the loop of Henle, and moves to the distal convoluted tubule and the connecting tubule [8]. Surrounding this tubular system is the peritubular capillary network, which provides oxygen and nutrients to sustain the renal tubules [9].

Renal abnormalities, whether structural or functional, can lead to acute kidney injury (AKI), a reversible condition that, if left untreated, may lead to chronic kidney disease (CKD) [10,11]. CKD is characterized by structural and functional changes in the kidney over three months or more, with a glomerular filtration rate (GFR) below 60 mL/min/1.73 m^2 [12,13]. CKD is classified into six stages: G1 to G5, where stage G3 is subdivided into G3a and G3b. These stages are defined by GFR magnitudes and are further categorized by levels of albuminuria (A1, A2, A3), which is measured by the albumin-to-creatinine ratio (ACR). The progression of CKD from mild (G1, G2) to severe (G4, G5) stages significantly impacts kidney function and requires interventions like renal replacement therapy (RRT) when end-stage renal disease (ESRD) is reached [14].

RRT encompasses dialysis and kidney transplantation. Dialysis serves as a life-sustaining treatment by removing waste products and excess fluid from the blood, either through hemodialysis or peritoneal dialysis [15,16]. Hemodialysis, the most common form, uses a machine to filter blood through a semi-permeable membrane. Blood is drawn from the patient, filtered in the machine, and returned to the body. Each session lasts about four hours and is conducted three times a week [14]. This method is highly effective in removing toxins and fluids, administering medications, and managing acute situations like pulmonary edema. However, it is associated with complications such as infections, muscle cramps, hypotension, and vascular access issues [17]. Peritoneal dialysis involves inserting a catheter into the abdominal cavity, where a dialysate absorbs waste products and drains them out of the body. This method is typically chosen for its simplicity and patient independence [18,19].

Chronic dialysis is required for individuals with irreversible renal failure unless they are eligible for a kidney transplant. For acute kidney injury, dialysis may be a temporary solution until kidney function recovers [20]. The principles of hemodialysis include diffusion, osmosis, and ultrafiltration. Diffusion allows the movement of solutes from higher to lower concentration, osmosis removes excess water, and ultrafiltration eliminates water under high pressure [21]. Hemodialysis systems are complex and self-contained, featuring detectors, monitors, and controllers to ensure safe operation. These systems consist of the extracorporeal blood circuit, dialysate delivery system, and dialyzer. Blood is circulated through the dialyzer, where solute and fluid removal occur, and returned to the patient.

The adequacy of hemodialysis is assessed utilizing parameters like the delivered dose, expressed as KdT/V (clearance multiplied by time and normalized by volume) [22]. This measure helps determine whether the prescribed dialysis effectively removes solutes like urea. Achieving an optimal dose depends on the dialyzer's performance, which can vary due to clotting, equipment

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defects, or interruptions during treatment. Factors such as accurate monitoring, proper reprocessing of dialyzers, and ensuring countercurrent blood and dialysate flow are critical for maintaining dialysis efficiency. Additionally, advancements in dialyzer technology, such as high-flux membranes, have improved clearance rates, offering faster and more effective treatments [23].

The indications for initiating hemodialysis include acute kidney injury, uremic encephalopathy, life-threatening hyperkalemia, refractory acidosis, pulmonary edema, and asymptomatic GFR below 10 mL/min/1.73 m² [24]. However, certain conditions, like an inability to secure vascular access or severe coagulopathies, may contraindicate hemodialysis [25]. In such cases, modern techniques can improve vascular access, but the patient's quality of life must also be considered when deciding on dialysis initiation [26].

The duration of dialysis treatments varies based on the underlying kidney condition. Chronic kidney disease requires lifelong dialysis unless transplantation is possible [27]. In contrast, acute kidney injury often necessitates temporary dialysis until renal recovery occurs. Hemodialysis sessions generally last four hours, but high-flux dialysis, which uses more permeable membranes, may reduce treatment time [28]. Patients are encouraged to discuss options with their healthcare providers to identify the most suitable approach [29].

The aim of this study is to evaluate the delivered dose of dialysis among patients with chronic kidney disease in Iraq. Specifically, it seeks to identify the prevalence of low delivered dialysis dose among patients, examines the relationship between Kt/V (a measure of dialysis adequacy) and various sociodemographic and medical factors, and explore the association between Kt/V and dialysis characteristics to better understand the factors influencing dialysis effectiveness in this population.

2. Methodology

2.1. Study design & Setting

A cross-sectional observational study was conducted in a single dialysis center of the Medical City Complex in Baghdad City to evaluate the delivered dose of dialysis among patients with chronic kidney disease in Iraq.

2.2. Study time

The time of study were 6 months from 1st of April 2024 to end of October.

2.3. Study population

All patients who were diagnosed with ESRD and were on regular HD were enrolled in this study. There were both gender (male and female) during the study period and selected according to specific criteria. Patient Selection The trial was planned as a study with all eligible patients of study center, thus a cross-section of those patients complying with the inclusion criteria (adult age, physical and mental ability to participate in the study, treatment with HD, and signed informed consent).

2.3.1. *Exclusion Criteria*

Exclusion criteria for the study encompassed a range of factors to ensure the accuracy and validity of the findings. This included pregnancy (a standard criterion for female patients), the

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use of single-needle dialysis (as the OCMs were designed for double-needle dialysis), and the presence of pacemakers or implanted pumps, which could interfere with bioimpedance measurements. Additionally, patients with major limb amputations were excluded due to reduced measurement accuracy, as were those with vascular access other than the intended type. Other exclusions included prior immunosuppressive treatment, active inflammatory diseases, clinical signs of acute infection, liver disease, malignancy, and evidence of blood loss or gastrointestinal bleeding.

2.4. Sampling size

We selected a convenient sample, which included 100 patients suffering from CKD who were attending the dialysis center of the medical city for hemodialysis in study time.

2.5. Methods

Modern dialysis machines are equipped with advanced online monitoring systems capable of calculating dialysis doses in real time. These systems not only measure the total delivered dose during a hemodialysis session but also monitor the clearance process and provide immediate feedback for online adjustments, ensuring consistently adequate dialysis for patients. By utilizing conductivity or UV-absorbance measurements in the dialysate, these systems enable the online calculation of Kt/Vurea without requiring blood or dialysate samples. For hematological and biochemical analyses, blood samples were collected prior to hemodialysis, utilizing EDTA tubes for hematology and non-anticoagulated tubes for biochemical tests (Ca, K, HCO3, Na).

2.6. Study Definitions

The Urea Reduction Ratio (URR) is a key metric for evaluating dialysis efficacy, reflecting the percentage reduction in urea levels achieved during a dialysis session and serving as an indicator of waste removal efficiency. Another widely utilized parameter for assessing dialysis adequacy is Kt/V. In this calculation, KKK represents the dialyzer clearance, denoting the rate at which blood is filtered through the dialyzer, expressed in milliliters per minute (mL/min); ttt refers to the duration of the dialysis session. The numerator (KtKtKt) signifies the total volume of fluid cleared of urea during a single treatment, while the denominator (VVV) corresponds to the patient's total body water volume, thereby providing a comprehensive measure of treatment adequacy.

2.7. Data collection

A structured questionnaire is developed to collect information from the participation. The subtending was conducted by the researcher.

2.7.1. *Questionnaire*

A structured questionnaire is the base for data collection developed by the researcher and reviewed by the supervisor and it consists of:

- The demographic information includes code NO., age, sex, height weight and BMI
- Disease information includes patient complaints, duration, past medical history (DM, HPT and comorbidities) and past drug history.
- Hemodialysis information: time per week, duration of HDF, blood loss , access , temperature and fluid drainage.

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- Measurement information: all tests (The pre- and post-dialytic urea concentrations, pre- and post-dialytic body weight, Qb, Qd, Ca, Na,K and the dialysis dose Kt/ V.

2.8. Statistical Analysis

The data was converted into a digital database format. Statistical analyses were conducted with SPSS (Statistical Package for the Social Sciences). Version 26 of the computer program for Windows. Data are presented as mean ± standard deviation (SD), along with frequencies (count) and percentages (%). It has been utilized for a student's t-test and one-way analysis of variances to compare means. The Chi-square test was utilized to compare frequencies and assess the significance of the connection between categories of variables with respect to P. A magnitude of < 0.05 was statistically significant.

2.9. Ethical consideration

The study was conducted in accordance with the approval of the Ministry of Health (MOH) in Iraq and the Medical City Directorate of Health. All collected data were treated with strict confidentiality and were not disclosed except for the purposes of the research. Participants were informed that their involvement was entirely voluntary and that they retained the right to withdraw from the study at any point, even after initially providing consent, ensuring adherence to ethical research standards.

3. Results

The current study included 100 patients suffering from chronic kidney disease who are undergoing hemodialysis treatment. 44% of them were male and 56% were female, with a mean age of the study sample being 51.5 years. The most common age group was over 45 years (74%). The mean of body mass index was (49.55 kg/m²) with 35% of the participants suffering from obesity and 92% having a previous medical history as illustrated in table 1 and figure 1.

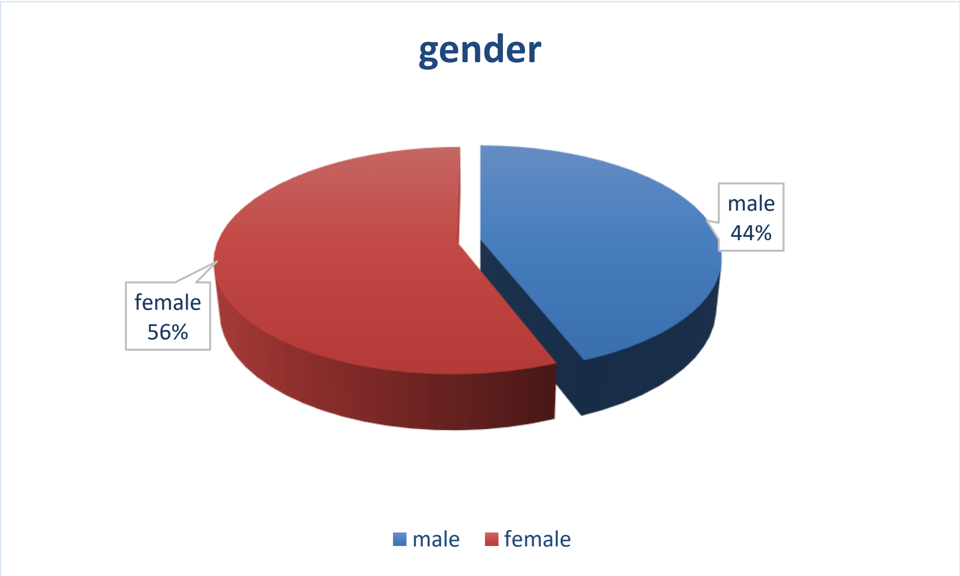

Figure 1: pie chart of gender distribution

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In terms of dialysis characteristics, the findings of the current study illustrated that 62% of the patients had two sessions per week, 34% received three sessions per week, and only 4% received one session per week. In reference to the study sample, the mean dialysis duration was 3.65, according to the data. The most popular dialysis access method was the arteriovenous fistula (68%), followed by the DL.catheter (24%), with the peri catheter being utilized by just 8% of patients. According to Table 2,

Table 1: distribution of study samples according to sociodemographic characteristics.

gender	Frequency	Percent
female	56	56
male	44	44
Total	100	100%
Age	Frequency	Percent
<45years	26	26
≥45years	74	74
Total	100	100
BMI	Frequency	Percent
Obese	35	35
Normal or low	65	65
Total	100	100%
PMHX	Frequency	Percent
-VE	8	8
+VE	92	92
Total	100	100

Table 2: distribution of study samples according to hemodialysis characteristic

Session number /week	Frequency	Percent %
1	4	4
2	62	62
3	34	34
Total	100	100
Duration of hemodialysis	Main	S.D
	3.650	.3813
Access	Frequency	Percent %
AV fistula	68	68
DL	24	24
peri catheter	8	8
Total	100	100

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In the current study, the findings illustrated that 58% of the participants had received a low delivered dose with no significant correlation to the age group. While the findings illustrated that 69% of the participants with a low delivered dose were female, with a statistically significant correlation with gender (p=0.002). As illustrated in Table 3 and Figure 2

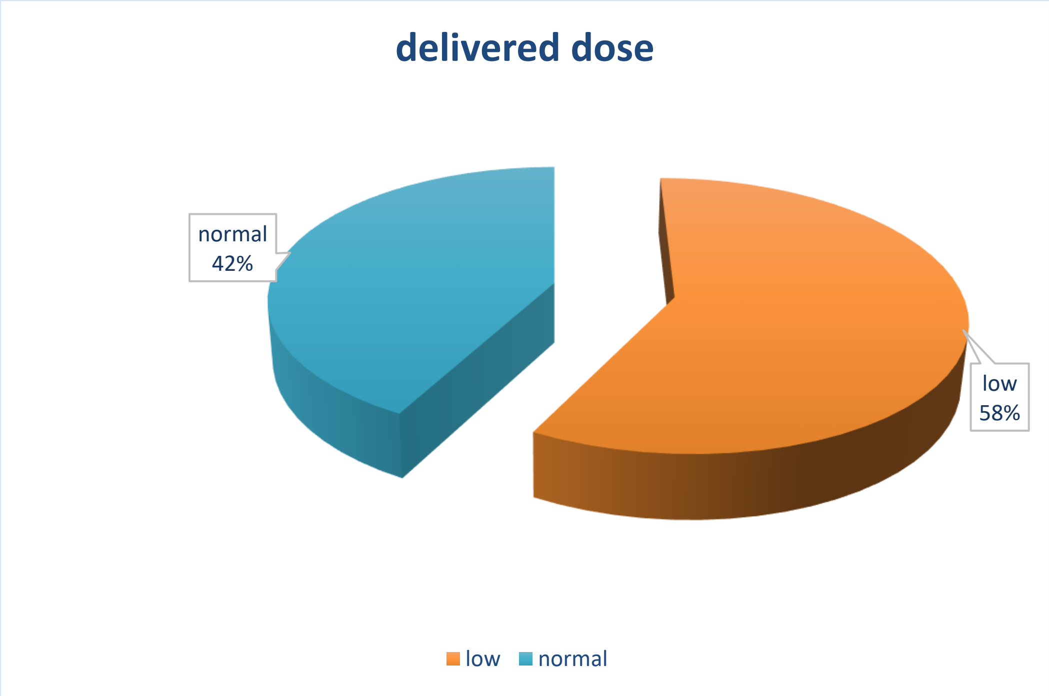

Figure 2: pie chart of delivered dose of participants

Table 3: relationship of delivered dose with age and gender of participants

Variables	Delivered dose		Total	P magnitude
age2	low	normal		
<45years	12	14	26	0.314
	20.70%	33.30%	26.00%	
>45years	46	28	74	
	79.30%	66.70%	74.00%	
Total	58	42	100	
	100.00%	100.00%	100.00%	
gender	low	normal	Total	P magnitude
female	40	16	56	0.002*
	69.00%	38.10%	56.00%	
male	18	26	44	
	31.00%	61.90%	44.00%	
Total	58	42	100	
	100.00%	100.00%	100.00%	
Pearson Chi-Square df=2 statically significant*				

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In the current study, the findings did not show any statistically significant correlation between the delivered dose and the number of dialysis sessions per week, while there was a statistically significant correlation with access types (where most of those with a low dialysis dose were among the participants who had DL. As illustrated in Table 4

Table 4: Relationship of delivered dose with hemodialysis characteristic of participants

Session	Delivered dose		Total	P magnitude
	Low	Normal		
1	4	0	4	0.206
	6.90%	0.00%	4.00%	
2	34	28	62	
	58.60%	66.70%	62.00%	
3	20	14	34	
	34.50%	33.30%	34.00%	
Total	58	42	100	
	100.00%	100.00%	100.00%	
Access	low	normal	Total	P magnitude
AV fistula	32	36	68	0.003*
	55.20%	85.70%	68.00%	
DL	20	4	24	
	34.50%	9.50%	24.00%	
peri catheter	6	2	8	
	10.30%	4.80%	8.00%	
Total	58	42	100	
	100.00%	100.00%	100.00%	
Pearson Chi-Square df=2 statically significant*				

Regarding the relationship between the delivered dose and the duration of dialysis, the result found that most participants with a lower delivered dose were among those with a shorter duration of dialysis, with a statistically significant correlation (p=0.001). According to Table 5 and figure 3

Table 5: relationship of delivered dose with hemodialysis duration of participants

Variables	Delivered dose	N	Mean	Std. Deviation	P magnitude
duration	low	58	3.5	0.374	0.001*
	normal	42	3.857	0.276	
Independent sample T test		statically significant*			

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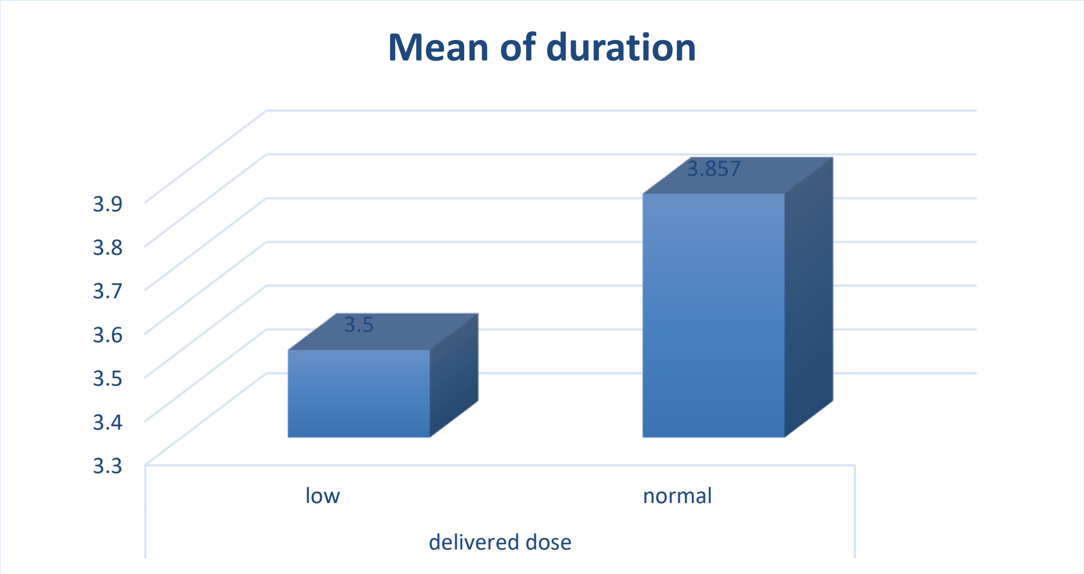

Figure 3 : relationship of delivered dose with hemodialysis duration of participants

Regarding the relationship between the delivered dose and BMI, the result found that most participants with a lower delivered dose were among those who were normal or low BMI, with a statistically significant correlation (p=0.02). As illustrated in table 6 and figure 4

Table 6: relationship of delivered dose with BMI of participants

BMI	Delivered dose		Total	P magnitude
	low	normal		
obese	15	20	35	0.02*
	25.90%	47.60%	35.00%	
normal	43	22	65	
	74.10%	52.40%	65.00%	
total	58	42	100	
	100.00%	100.00%	100.00%	
Pearson Chi-Square df=2 statically significant*				

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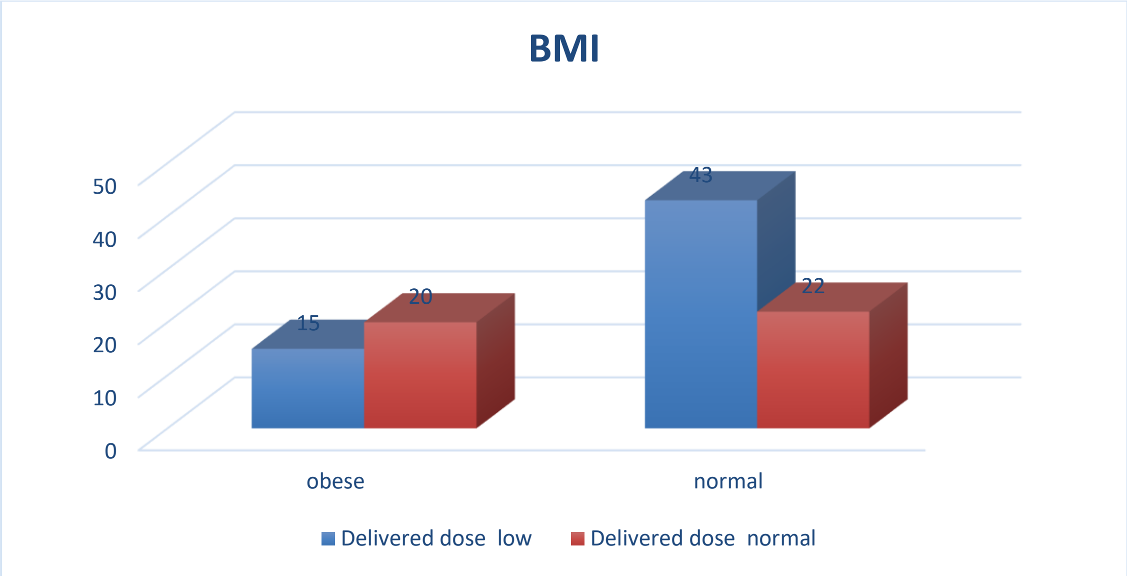

Figure 4: relationship of delivered dose with BMI of participants

In term to the relationship between the delivered dose and past medical history, the result found that most participants with a lower delivered dose were among those who were positive past medical history 98.3% , with a statistically significant correlation (p=0.009). According to Table 7 and figure 5.

Table 7: relationship of delivered dose with past medical hx of participants

Past medical history	Delivered dose		Total	P magnitude
	low	normal		
negative	1	7	8	0.009*
	1.70%	16.70%	8.00%	
positive	57	35	92	
	98.30%	83.30%	92.00%	
Total	58	42	100	
	100.00%	100.00%	100.00%	
Fisher exact test df=2 statically significant*				

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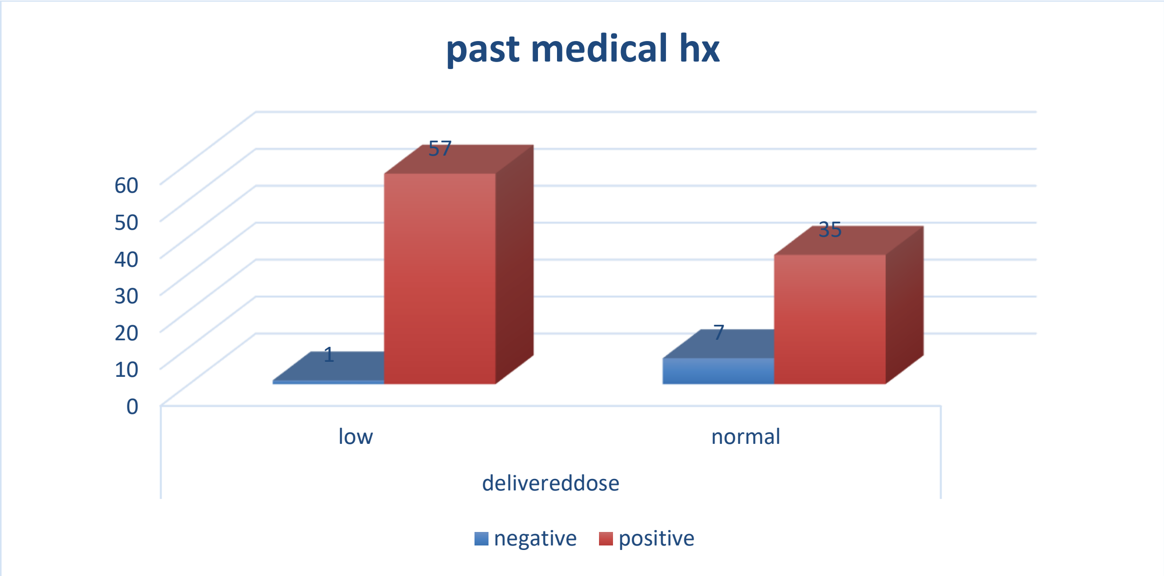

Figure 5: relationship of delivered dose with past medical hx of participants

In addition to that, the result of the current study found that most participants with a lower delivered dose were among those who had mean of QP and Qd lower than normal (268.24 and 473.45 respectively) , with a statistically significant association (p=0.001 and 0.022 respectively). As illustrated in Table 8 and figure 6.

Table 8: relationship of delivered dose with blood flow of participants

Variables	Delivered dose	N	Mean	Std. Deviation	P magnitude
Qp	low	58	268.24	58.792	0.001*
	normal	42	302.05	5.392	
Qd	low	58	473.45	84.885	0.022*
	normal	42	504.76	21.554	
Independent sample T test df=98 statically significant*					

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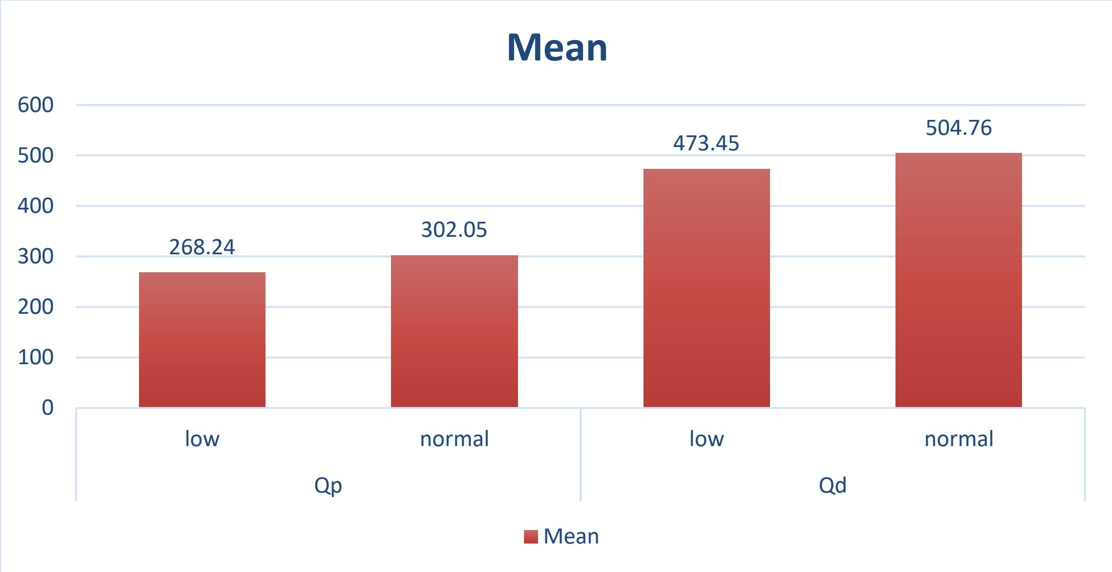

Table 6: relationship of delivered dose with blood flow of participants

4. Discussion

The morbidity and mortality of haemodialysis (HD) patients are influenced by insufficient dialysis. Dialysis insufficiency may be assessed by many methods, with urea clearance procedures, determined by Kt/V and urea a decrease proportion (URR), being the most recommended indicators of dialysis efficacy in medical practice [30].

Kt/V [K: dialyser clearance (mL/min); t: dialysis time (min); V: urea distribution volume (mL)] remains the principal metric for assessing dialysis adequacy [31]. The HEMO study, a pivotal randomized controlled trial undertaken in 2002, indicates that a single-pool Kt/V (spKt/V) lower than 1.2 is associated with a reduced death rate in hemodialysis patients [32]. KDOQI guidelines for patients undergoing treatment three times weekly stipulate a min deliverable spKt/V of 1.25 and a target spKt/V of 1.4 for each hemodialysis session. In clinical practice, the Taiwan Society of Nephrology utilises URR, recommending a minimum URR of more than 65%.

Kt/V has always been favoured above URR as the benchmark for determining HD dose and is endorsed by the KDOQI. Nonetheless, Kt/V has potential drawbacks that may outweigh its advantages, a topic that has been deliberated in recent decades [33]. The present investigation's findings indicate that 58 percent of participants had a decrease in their Kt/V magnitude. The predictive magnitude of Kt/V varies based on certain situations and demography. Kt/V might have increased in those with diminished V. While many study findings are inconsistent, others have illustrated that body weight modifies the relationship between all-cause mortality and Kt/V. Moreover, several research have illustrated that dialysis dose may be affected by gender, weight, and activity level [34]. It was illustrated that this effect may be influenced by female sex but not by low weight [35].

Multiple retrospective investigations have illustrated that a Kt/V greater than 1.2 correlates with improved survival rates. In a research done by Chen YK et al. [36], it was revealed that

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parameters including weight, age, and other comorbidities did not alter the connection with Kt/V, except for a significant correlation between sex and low Kt/V. Research has illustrated that underdialysis is more prevalent in women, elucidating this sex difference. Recent investigations revealed that the min target dialysis doses of Kt/V varied among sedentary patients based on gender and body size. When alternative parameters including Kt/TEE (Total Energy Expenditure) and Kt/BSA (Body Surface Area) were employed, it was observed that women and smaller men were generally subjected to underdialysis when assessed utilizing Kt/V [34,35]. A recent research in the Gulf Cooperation Council (GCC) population revealed that low Kt/V is significantly associated with increased mortality in women, but not in males [37]. Perez-Garcia et al. revealed that patients with elevated Kt/V, more prevalent in women, had worse survival rates compared to their counterparts. Elevated Kt/V levels result from a diminished V and suboptimal nutritional state. Furthermore, female haemodialysis patients exhibited more pronounced malnutrition and reduced albumin levels, negating the advantages of a comparatively elevated Kt/V [38]. The malnutrition issue complicates the assessment of the true advantages of enhanced dialysis dose in women as measured by Kt/V. A further research identified a comparable sex disparity in mortality advantage for women undergoing haemodialysis in Japan with spKt/V magnitudes > 1.6 [39].

The findings of the present research suggest that the impact of dialysis dosage in dialysis patients may be affected by body mass index (BMI). Patients with a low body mass index (BMI) had an elevated risk of reduced spKt/V in contrast to those with a normal BMI and spKt/V within the desired range. This agreement with Hong WP et al. [40] indicates a substantial positive correlation between elevated spKt/V above 1.2 and HD patients with a BMI below 23 (low and normal BMI). These findings align with the findings of Port et al., who established a substantial correlation between the standard administered dosage and enhanced survival rates in small and medium BMI cohorts undergoing HD [41]. Furthermore, Wang et al. indicated that augmenting dialysis dosage in overweight haemodialysis patients did not enhance health-related quality of life [42]. The disparities between the high and low body mass index categories identified in research may be elucidated via several mechanisms. The complicated malnutrition-inflammation syndrome and protein-energy loss likely account for the correlation between low body mass index and heigh mortality in dialysis patients. The enhancement of dialysis efficacy was correlated with improved nutritional status, both of which are associated with enhanced survival rates. Nevertheless, a high body mass index (BMI) may also signify good nutritional health and is unlikely to be influenced by the advantages linked to enhanced dialysis efficiency [41].

Dialysis parameters illustrated significant variation across Arab nations, particularly in terms of attained Kt/V levels and types of vascular access [42]. Patient-level studies revealed a significant correlation between reduced Kt/V accomplishment and factors such as shorter duration, lower blood flow rates, and higher comorbidity ratings [37]. Other investigations have also illustrated a correlation between shorter duration and reduced blood flow rate with decreased dialysis dosage [43–45]. The catheter may influence the mean blood flow rate (BFR) by diminishing the attained Kt/V [46]. These may arise from mechanical failure (catheter kinking or catheter compression against the vascular wall) or thrombosis (internal intraluminal thrombosis, external thrombosis, catheter-associated thrombus, or a fibrin sheath) [47]. Nonetheless, our multivariate analyses did not reveal a significant correlation between catheter use and low attained Kt/V, although a potential trend was seen. Moreover, prior research indicates that extending dialysis duration and

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enhancing blood flow rate might elevate Kt/V [48,49], while prolonged timeframes may also beneficially influence patient life subsequent to attaining Kt/V [50].

Research conducted in the 1990s indicated that Ktv could be augmented by enhancing Qd; this aligns with our findings. However, acknowledging that inadequate flow distribution within the dialysate compartment could result in preferential dialysate flow in the external region of the bundle, leading to stagnation in the internal area of the haemodialyser, manufacturers of dialysers instituted several modifications to their designs [51]. Clinical studies have been published examining the impact of raising Qd with various dialyzers. Alayoud [52] advocates for AF due to its capacity for a Qd of 400 ml/min, however Kashiwagi asserts that the flow ratio Qb/Qd must be maintained at 1:2 to achieve optimal dialysis efficiency [53]. Conversely, Ward et al. [54] discovered that increasing the dialysis solution flow rate from 600 to 800 ml/min does not alter the Kt/Vurea, as measured by both blood-based and dialysis solution-based techniques. The disparity in outcomes might be attributed to variations in sample size, inclusion criteria, and research conditions. A significant disadvantage of this research is that it was performed at a single dialysis centre in Baghdad with a limited sample size. The restricted specimen size and considerable variability in KT/V magnitudes across individuals are probable variables influencing statistical significance. Future study might require the examination of bigger specimens across various age groups.

5. Conclusion

The findings of this study revealed that over half of the participants experienced suboptimal delivered dialysis doses, with statistically significant associations observed between the delivered dose and factors such as gender, duration of dialysis, body mass index (BMI), presence of chronic diseases, and dialysis flow rate. These findings underscore the multifaceted nature of dialysis adequacy, highlighting the interplay of patient-specific factors and treatment parameters. The strong correlation with dialysis flow emphasizes the critical need for precise optimization of flow rates to enhance treatment efficacy. Additionally, the influence of demographic and clinical variables, such as gender and chronic disease prevalence, suggests a necessity for tailored interventions to address individual patient needs. These insights provide a robust foundation for refining dialysis protocols and implementing targeted strategies aimed at improving delivered dose adequacy, ultimately contributing to better clinical outcomes and quality of life for patients undergoing maintenance dialysis.

6. Recommendation

- Conducting research on a larger number of patients to identify and evaluate more factors that were not analyzed in this study and that may affect the research findings.
- Conduct case-control studies to identify the main causes and risk factors for the decrease in KTV.
- More follow up to patients for decrease the morbidity and mortality of patients

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