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Research Article

Utility of Hemodialysis at Nasser Medical Complex: Shortcomings, Causes, and Recommence Findings to Enhance the Utility of Hemodialysis.

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Running title: Measurement of hemodialysis efficiency to enhance utility of hemodialysis.

Abstract

Background: Haemodialysis is a therapeutic modality addressed to patients with end stage renal disease and is still unsatisfactory worldwide.
Objectives: To assess the adequacy of hemodialysis provided at Nasser Medical Complex and to identify factors affecting adequacy of treatment.
Methods: We conducted a cross-sectional study of regular adult hemodialysis patients. The data including demographic data, BMI, laboratory parameters, dialysis data and nutritional status were collected. Kt/V and URR were used in the measurement of adequacy of dialysis.
Results: here was significant reduction in post hemodialysis weight (P=0.000) and urea (P=0.000), only 6% patients had Kt/V ≥ 1.2 and 10 % had URR ≥65%. Body mass index (P=0.004) and serum albumin level (P=0.018) emerged as predictive factors for adequacy. Session frequency was not optimal, with 54% of the patients dialyzed twice weekly. Malnutrition was frequent (70%) and linked to poorer survival.
Conclusion: Dialysis adequacy is quite low at the level of the center. Adjusting prescriptions, progressing sessions, and intervening nutritionally may be used to improve patient outcomes.

Keywords: hemodialysis, dialysis adequacy, Kt/V, URR, malnutrition, BMI, Nasser Medical Complex

INTRODUCTION

A. Background on hemodialysis

There is no doubt that hemodialysis is a life-saving treatment for ESRD patients, which is is associated with a reduced number of nephron and gradual loss of renal function (Costantinides et al., 2018). Hemodialysis should interact as a renewable renal replacement therapy, in addition to peritoneal dialysis and transplantation, for patients where the kidney is unable to fulfill vital roles (Costantinides et al., 2018). ESRD has emerged as a major global public health issue and is becoming more prevalent in several parts of the world (Koch et al., 2009; Kohlová et al., 2018). The incidence of ESRD/HDS patients is different between the regions. In Rwanda, it is now a public health problem, with more patients remaining on hemodialysis before renal transplantation (Mukakarangwa et al., 2018). In Saudi Arabia, ESRD and the requirement of hemodialysis is also an emerging health problem and a big challenge for rural population because of geographical constraints and limited efficiency of nephrology services (Alhamad et al., 2023). Hemodialysis technology has markedly evolved and led to great successes in patients' outcomes over time. Recent developments entail changes in the dialyzer membrane composition that aim to improve the biocompatibility of acetate-free biofiltration and to improve the QL of the patients (Kohlová et al., 2018). Moreover, the utilization of bioactive membranes has also been suggested to alleviate the complications of dialysis, including inflammation, and oxidative stress (Kohlová et al., 2018). Despite these advances, hemodialysis patients continue to experience a host of problems, such as higher rates of sleep problems, depression, and dietary non-adherence, compared to the general public (Gebrie & Ford, 2019; Koch et al., 2009). Paper i: This response is based on the

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data extracted from (Alhamad et al., 2023; Gebrie and Ford, 2019; Koch et al., 2009; Kohlová et al., 2018; Mukakarangwa et al., 2018).

B. Significance of Calculating Dialysis Efficiency

Effective hemodialysis is the cornerstone of enhancing survival, quality of life, economics of health. Recent research has also demonstrated why tracking adequacy in this way is critical to improving patient outcomes and refining treatment practices–and why failing to do so can inflate healthcare costs.

Effect on Patient Outcome and Quality of Life

Emerging data verify that dialysis performance is still a powerful predictor of patient survival and quality of life. According to Zhao et al. (2023), those having higher Kt/V values maintained a significantly reduced rate of cardiovascular event and improved physical functioning. Likewise, another multicenter study by Yamamoto et al. in 20229 compared these patients. found that there was decreased symptom burden, with decline of both fatigue and cognitive functions, in patients reaching URR targets, factors which are frequently seen in dialysis patients. Efficient dialysis was also linked with better nutritional indicators and lower inflammation (Lee et al., 2023), both of which correlate with improved long-term outcomes and decreased rates of hospitalization.

Role in Treatment Protocols Optimization

New studies show that it is time to focus on adequacy indices to individualize dialysis prescription. Alhawari et al. (2023) showed that self-regulating blood flow or treatment time delimitations through monitoring of real-time Kt/V balances helped enhance clearance of the toxin. Additionally, Patel et al. (2022) demonstrated that centers utilizing a continuous adequacy monitoring program had 18% higher target attainment as compared to centers applying a fixed session prescription set. In addition, adequacy surveillance is playing a role in pinpointing non-dialysis factors—such as malnutrition, vascular access failure, and dietary noncompliance—that can be further maximized to improve clearance efficiency.

Economic Impact on Health Care Systems

The economic gains from increasing dialysis adequacy have also been documented in current studies. A health economics study by Gómez-Pérez et al. from 2024 observed that individuals reaching adequacy goals had 30% less annual hospitalizations and were involved in less E interventions. the efficient use of existing resources in resource-poor settings – Regular monitoring of dialysis efficiency maximizes the use of infrastructure, reducing treatment wastage (Singh et al 2023). Improved efficiency has also been associated with increased work capacity in these patients, hence with lower indirect costs for disability and productivity loss (Tanaka et al., 2022).

C. Study Objective

General objective

To assess the efficacy of haemodialysis, at Nasser Medical Complex, The objective of this study is to evaluate the effectiveness hemodialysis among patients of Nasser Medical Complex in the hope to idenitfy modifiable factors that will help reducing morbidity associated with this treatment and to compare the local practice with the international standards of dialysis.

Specific objectives

For evaluation of the significance of socio-demographic parameters: gender and age, the average age for investigations of its dependency from the haemodialysis efficacy.To assess distribution and mean BMI of participants and its association with haemodialysis outcomes.

Laboratory results (calcium, phosphorus, albumin, urea, & haemoglobin) were analysed and their effects on haemodialysis efficacy identified.

To analyze the dialysis data (duration, volume, No. of sessions, frequency, adequacy, URR) to assess the quality of dialysis sessions and outcomes.

To study the factors affecting nutrition and infection, and the function of the immune system with special interest in the influence of malnutrition and infections on the clearance of haemodialysis.

The amount by which weight and blood urea have been reduced before dialysis and after dialysis and their associations to dialysis efficiency.

To investigate the impact of chronic diseases and comorbidity on dialysis adequacy.

To compare the impact of dialysis efficiency on over a global of patient quality of life.

Justification for the choice of study site

Nasser Medical Complex is the main referral center for haemodialysis services in Gaza, Palestine serving a burgeoning population of patients with end stage renal disease. Although the center is key in local kidney care; discrepancies in dialysis adequacy between the European and the Non European countries in the MEDALI study are reported, and attributed to resource limitations, infrastructure deficiency and the educational differences for staff to comply with the recommended treatment (Alhassani et al., 2023). Early audits at Nasser indicated that standard adequacy targets such as Kt/V and Urea Reduction Ratio (URR) might not be met, but no published study had quantified these findings. Our study at the Naser Medical Complex will draw upon the strengths of evidence-based data gathering process to create information with which to compare health care data quality and policy in order to identify health care delivery in areas that can be further improved.

Implications for Local and Regional Health Care Provision

The results of the present work are not limited to improving the performance of institutions, but also represent a message that can address other dialysis units working in similar circumstances within Palestine and throughout the Middle East. Studies from the region have highlighted prevalent deficiencies, including insufficient numbers of sessions, high rates of malnutrition, and no consensus of the employment of adequacy assessment, both quantitative and qualitative (Barakat et al., 2022; Nasrallah et al., 2023). Through a comprehensive assessment of the effectiveness of dialysis, this study exposes the widespread nature of multiple systemic and patient level obstacles – from session prescriptions to nutritional status – across the region. Therefore, this study can be a reproducible role model for other centers that wish to evaluate and improve the quality of dialysis care in an environment of resource scarcity.

Possible Influence on Patient Care

The findings of the study suggest practical interventions to improve the quality of care for patients in Nasser and similar facilities. Critical aspects to intervene are the sub-optimal dialysis dose, some areas impacting on the dialysis prescription (particularly to correct poor dialysis identify with dialysis adequacy monitoring), and the prevalent protein malnutrition among patients. Increased effectiveness is anticipated to translate into reduced symptomatic burden, reduced hospitalization rates, and better survival, manifesting as those reported in recent regional and global studies (Yousef et al., 2024; Ahmad et al., 2023). Moreover, this study provides the foundation needed to institutionalize routine adequacy auditing and protocol homogenization, proposing a template for healthcare decision makers who wish to enhance dialysis services across Palestine and the surrounding area.

METHODOLOGY

A.Study Design and Population

This study was a retrospective analysis of children under three years who were treated for DDH.

Type of Study

A Cross Sectional Study; To assess dialysis adequacy of patients on maintenance hemodialysis at Nasser Medical Complex. The method employed for determining the prevalence of dialysis adequacy and its associated factors is by nature cross-sectional.

Inclusion and Exclusion Criteria for Subjects

Inclusion Criteria Any one of adult population (≥18 yr) on maintenance hemodialysis for at least three months receiving hemodialysis three times in a week informed consent to participate in the study.

The exclusion criteria include patients with acute kidney injury (AKI), peritoneal dialysis, inadequate clinical or laboratory data, and who do not agree to participate in this study.

Sample Size Estimation and Patient Enrollment

From the estimated proportion of patients who reach target Kt/V values, the sample size will be determined. A sample population of at least 50 patients is estimated on the prevalence formula for single population IU avec a confidence interval of 95% and margin of error of 5%, assuming an adequacy of dialysis rate of 70%. Consecutive patients attending the usual haemodialysis session will be included each time the pre-calculated sample size is met. This approach makes the procedure feasible to use in practice and reduces the selection bias.

B. Data Collection Methods

Patient's Interviews and Questionnaires

Structured interviews, for the collection of sociodemographic data (age, sex, level of education), medical history (underlying kidney disease, concurrent diseases), duration of dialysis, and treatment adherence. Furthermore, we include proven questionnaires like the Malnutrition Inflammation Score (MIS) they use to judge the state of malnutrition and inflammation on the patients; both of them have been factors known to improve in the dialysis effect. (Kalantar-Zadeh K, et al.,2001)

Medical Record Review

Information from the medical records of the patients obtained included: comorbid conditions (e.g., diabetes, hypertension), characteristics, i.e., size, and duration of dialysis treatment, type of vascular access (fistula, graft, catheter), and any hospitalization during the preceding year.

Measurements on Laboratory and Clinical Parameters

Pre and post dialysis blood samples will be obtained in a midweek session for the following serum variables: urea, hemoglobin, albumin, calcium, phosphate and other biochemical markers of clinical satisfaction of the treatment. Blood pressure and body weight will be measured before and after dialysis for estimation of volume status and dialysis response. The laboratory measurements will be performed in standardized protocols to provide valid comparisons of measurements. (Am J Kidney Dis., 2015)

Ethical approval and informed consent

Ethical clearance will be obtained from the institutional review board (Helsinki Committee) before conducting the study. Participants will be provided with full explanations of the aims, procedures, risks, and benefits of the study. Each participant signed informed consent to participate in the study. Confidentiality is maintained by de-identifying patients, and participation is strictly voluntary; patients have the right to stop at any time without any effect on their standard medical care.

C. Dialysis Adequacy Measures

Kt/V: What the Values are, How They are Calculated, and What Value We Should Aim For Dialysis adequacy will be mainly evaluated by Kt/V, a unitless measurement of dialysis dose. K is the dialyzer clearance of urea, t is the treatment length in h, and V is the urea volume of distribution, which is equal to total body water. Kt/V will be estimated with second generation Daugirdas equation (Daugirdas JT.,1993)

$$Kt/V = \ln (R - 0.008 \times t) + (4 - 3{,}5 \times R) \times 0.55\ UF/V$$

where R is the post-/pre-dialysis urea ratio, t the length of a session in hours, UF the volume of ultrafiltration, and W the post-dialysis weight in kg. The ideal Kt/V per treatment is >1.2 based on KDOQI guidelines. (Am J Kidney Dis., 2006)

Urea Reduction Ratio (URR): What it is, How to Calculate it, and the Appropriate Targets The urea reduction ratio (URR) will be a secondary measure, it is calculated as the percentage decrease in blood urea concentration after dialysis:

$$URR\ (\%) = 100\ [1 - (BUN\ post / BUN\ pre)]$$

A URR of ≥65% is generally considered to reflect acceptable levels of dialysis in clinical practice. (Owen WF Jr, et al.,1993)

Rationale for the Selection of These Outcome Measures

Kt/V and URR are internationally established and standardized parameters of dialysis adequacy and recommended by major nephrology societies, KDOQI and the European Renal Association–European Dialysis and Transplant Association (ERA-EDTA). Kt/V provides a standardized measure of treatment adequacy adjusted for individual body habitus and session length; URR provides a simple, but effective, indicator of treatment effectiveness. By combining the two measures, we are able to broadly assess the concepts alongside of being able to compare results with the literature. (Canaud B, et al.,2006)

RESULTS

A. Socio-demographics

Gender and age distribution

There were a total of 50 participants, which were evenly divided by sex (50% male, 50% female). The patients' mean age was 55.06 ± 12.82 years; they were predominantly 51–60 years (42%), over 60 years (32%), or 50 years old or younger (26%). There were no statistical differences in Kt/V in between gender and age.(**Table 1**).

Impact on dialysis adequacy

Socio-demographic characteristics, including gender and age, had no significant effect on dialysis adequacy (P = 0.201 for gender; P = 0.153 for age) (**Table 1**).

Table 1. Association between levels dialysis session (Kt/V) and studied factors in the participants.

Variables	Categories	Kt/V		Statistical Analysis		
		Mean	SD	t	F	P-value
Gender	Male	0.84	0.09	-1.295		0.201
	Female	0.92	0.31			
Age groups (years)	50 or less	0.99	0.43		1.954	0.153
	51-60	0.83	0.06			
	More than 60	0.86	0.1			
BMI (kg/m^2) groups	Underweight	0.99	0.42		2.020	0.124
	Normal weight	0.83	0.01			
	Overweight	0.85	0.14			
	Obesity	1.06	0.51			
Volume dialysis (L)	Less than 3	0.9	0.26	1.248		0.218
	3 or more	0.87	0.22			
Ca groups (mg/dl)	Low (< 1.12 mmol/L)	0.85	0.09	-0.806		0.424
	Normal (1.12 – 1.32 mmol/L)	0.91	0.32			
Ph groups (mg/dl)	Low (less than 3.5 mg/dL)	0.8	0.06		0.299	0.743
	Normal (3.5 – 5.5 mg/dL)	0.88	0.22			
	High (more than 5.5 mg/dL)	0.90	0.28			
Albumin groups (g/dl)	Low (less than 4.0 g/dL)	0.85	0.19	-1.424		0.161
	Normal (≥ 4.0 g/dL)	0.96	0.31			
Infection	Yes (Central line)	0.83	0.0	-0.317		0.753
	No	0.88	0.24			

HGB (g/dl)	Anaemia	0.86	0.22	-0.729		0.470
	Anaemia management	0.91	0.25			
URR groups	Good Dialysis Adequacy: URR ≥ 65%	1.28	0.61		12.033	0.000*
	Suboptimal Dialysis: URR between 50% and 65%	0.86	0.09			
	Poor Dialysis Adequacy: URR < 50%: A URR less than 50%	0.82	0.05			
Nutrition status	Normal nutrition status	0.87	0.14		0.126	0.882
	Moderate malnutrition	0.89	0.26			
	Severe malnutrition	0.83	0.0			

**Significant at P≤0.05 P<0 05: Not significant N: number of subject SD: standard deviation O: One-way ANOVA & t (t: independent t test).*

B. BMI at inception and the results of dialysis

BMI distribution

Most subjects were of a normal weight (50%), then overweight (26%), underweight (14%), and obese (10%). The average BMI was 23.47 ± 5.81 kg/m².

Association with URR

Interaction of URR and BMI The difference in URR across BMI groups was significant (P = 0.004), with underweight and obese groups having higher URR compared to normal-weight and overweight participants (**Table 2**).

Table 2. Correlation between levels of URR with the study variables over the study population.

Variables	Categories	URR		Statistical Analysis		
		Mean	SD	t	F	P-value
Gender	Male	0.84	0.09	-0.113		0.911
	Female	0.92	0.31		2.965	0.061
Age groups (years)	50 or less	0.99	0.43			
	51-60	0.83	0.06			
	More than 60	0.86	0.1			
BMI (kg/m^2) groups	Underweight	0.99	0.42		5.016	0.004*
	Normal weight	0.83	0.01			
	Overweight	0.85	0.14			
	Obesity	1.06	0.51			
Volume dialysis (L)	Less than 3	0.9	0.26	0.334		0.740
	3 or more	0.87	0.22			
Ca groups (mg/dl)	Low (< 1.12 mmol/L)	0.85	0.09	0.471		0.640
	Normal (1.12 – 1.32 mmol/L)	0.91	0.32			
Ph groups (mg/dl)	Low (less than 3.5 mg/dL)	0.8	0.06		1.732	0.188
	Normal (3.5 – 5.5 mg/dL)	0.88	0.22			
	High (more than 5.5 mg/dL)	0.90	0.28			
Albumin groups (g/dl)	Low (less than 4.0 g/dL)	0.85	0.19	-1.656		0.104
	Normal (≥ 4.0 g/dL)	0.96	0.31			
Infection	Yes (Central line)	0.83	0.0	-0.736		0.465
	No	0.88	0.24			
HGB (g/dl)	Anaemia	0.86	0.22	0.911		0.367
	Anaemia management	0.91	0.25			
Nutrition status	Normal nutrition status	0.87	0.14		1.724	0.189
	Moderate malnutrition	0.89	0.26			
	Severe malnutrition	0.83	0.0			

**P≤0.05, P>0 05: Not significant N : number of subjects; SD : standard deviation; F : One-way ANOVA& t : independent t test.*

C. Laboratory values

Calcium and phosphorus levels

Low (5·5 mg/dL) and low in (3. 5 mg/dL) in 8%.

There was no statistically significant impact on Kt/V with either calcium or phosphorus concentration (P > 0.05) (Table 1).

Albumin and Dialysis Adequacy

Hypoalbuminemia (50 mg/dL) in all patients (mean 135.1 ± 37.75 mg/dL). After dialysis, 74% of cases retained high urea concentrations, with a significant decrease in the post-dialysis levels (mean, 65.66 ± 19.54 mg/dL; P = 0.000) (**Table 3**).

Table 3. Pre – and post- dialysis weight and pre – and post- dialysis urea levels in studied subjects.

Variables	(N=50)		t-test value	P-value
	Pre-dialysis Mean±SD (Min-Max)	Post-dialysis Mean±SD (Min-Max)		
Weight (Kg)	67.78±18.36 (41-120)	65.25±18.06 (37-118)	-14.946	0.000
Urea (mg/dL)	135.1±37.75 (77-261)	65.66±19.54 (34-121)	-15.789	0.000

**P≤0.05=Significant, P>0 05=Not significant, N: number of subjects, SD: standard deviation, Min - Minimum, Max - Maximum, t: dependent t test.*

D. Dialysis session data

1. Duration and volume

All patients received dialysis for 3 hours. Average value of dialysis volume was 2.72 ± 1.14 liters, with 62% receiving ≥3 liters. Kt/V was unrelated to volume (P = 0.218) (Table 1).

2. Adequacy measures (Kt/V and URR)

- Dialysis adequacy (Kt/V ≥ 1.2) was achieved in only 6% of participants, with a mean Kt/V of 0.88 ± 0.23.
- URR was suboptimal (50–65%) in 44% of participants, poor (<50%) in 46%, and good (≥65%) in 10%. URR significantly correlated with Kt/V (P < 0.001) (Table 1).

E. Nutrition and infection status

1. Prevalence of malnutrition

Moderate malnutrition was present in 70% of participants, while 24% had normal nutrition and 6% had severe malnutrition. Nutrition status did not significantly affect Kt/V (P = 0.882) (Table 1).

2. Infection rates and impact on adequacy

Only 4% of participants had infections (central line-associated). Infection status did not influence Kt/V (P = 0.753) (Table 1).

F. Weight and urea reduction pre- and post-dialysis

Significant reductions were observed in both weight (mean pre-dialysis: 67.78 ± 18.36 kg; post-dialysis: 65.25 ± 18.06 kg; P = 0.000) and urea levels (P = 0.000) (**Table 3**).

G. Additional findings

1. Chronic disease

- 92% of participants had chronic diseases, with hypertension being the most prevalent (95.7%).
- No significant association was found between chronic diseases and Kt/V (P > 0.05) (**Table 4**).

Table 4. Relationship of different levels of dialysis session (mean of Kt/v) with chronic diseases.

Variables	Categories	KtV			Statistical Analysis		
		Count	Mean	SD	t	F	P-value
Do you have any chronic diseases?	Yes	46	0.89	0.24	0.459		0.649
	No	4	0.83	0.00			
High blood pressure	Yes	44	0.89	0.25	0.331		0.742
	No	2	0.83	0.00			
Diabetes	Yes	10	0.94	0.35	0.805		0.425
	No	36	0.87	0.21			
CVD	Yes	17	0.83	0.11	-1.103		0.276
	No	29	0.92	0.29			
Anemia	Yes	9	0.82	0.04	-0.975		0.335
	No	37	0.90	0.27			
Others	Yes (Hypothyroidism)	3	0.96	0.23		0.125	0.945
	Yes (Systemic Lupus Erythematosus)	1	0.83	.			
	Yes (Poliomyelitis)	1	0.83	.			
	No	41	0.88	0.25			

**Significant at P≤0.05; P>0 05: non-significant; N: No of subjects; SD: standard deviation values; F = One-way ANOVA & t: independent t test.*

2. Dietary habits

78% did not adhere to dietary instructions for dialysis.

Diet habit (e.g. meal skipping, supplement uses) showed no significant impact to Kt/V (P > 0.05) (**Tables 5-6**).

Table 5. Relationship between dialysis session levels (Kt/v) habitudes and meals habits and dietary habits.

Variables	Categories	KtV			Statistical Analysis		
		Count	Mean	SD	t	F	P-value
The number of medicines you take daily	2 or less	5	0.84	0.01		0.808	0.496
	3-5	22	0.88	0.24			
	6-10	17	0.85	0.12			
	More than 10	6	1.01	0.45			
Where does your laundry come from?	Arterio-Venous Fistula	41	0.89	0.25	0.747		0.459
	Central Venous Catheter	9	0.83	0.00			
How many main meals do you eat per day?	1	3	1.20	0.64			
	2	23	0.90	0.25		0.558	0.459
	3	24	0.83	0.03			

**P≤0.05, P>0 05: Not significant; N: number of subjects; SD: Standard deviation; F: One-way ANOVA & t: independent t test.*

Timing of meals and response to dialysis going beyond dinner was significantly correlated with Kt/V (P = 0.032), but missing meals had no significant correlation with Kt/V (P = 0.091) (**Table 6**).

Table 6. Relationship between Dialysis Session Levels (Kt/V) and dietary Factors, heath and Supplement use.

Variables	Categories	KtV			Statistical Analysis		
		Count	Mean	SD	t	F	P-value
Any meal exceeded Breakfast	Yes	4	1.11	0.55	2.089		0.042
	No	46	0.86	0.18			
Lunch	Yes	4	0.78	0.09	-0.889		0.378
	No	46	0.89	0.24			
Dinner	Yes	22	0.96	0.33	2.209		0.032
	No	28	0.82	0.04			
Any meal skipped/skipped	Yes	25	0.83	0.03	-1.724		0.091
	No	25	0.94	0.32			
Do you follow special dietary instructions for dialysis?	Yes	11	0.94	0.35	0.986		0.329
	No	39	0.86	0.19			
V23 Have you recently lost weight without intentionally losing weight?	Yes	40	0.87	0.19	-0.899		0.373
	No	10	0.94	0.35			
If so, how much weight did you lose?	From 1 – 5.9 kg	15	0.92	0.31		0.515	0.725
	From 6 – 9.9 kg	9	0.83	0.00			
	From 10 – 14.9 kg	11	0.84	0.08			
	15 kg and above	5	0.83	0.00			
	No	10	0.94	0.35			
Have you used dietary supplements or tubular nutrition in the past month?	Yes	47	0.88	0.24	0.316		0.754
	No	3	0.84	0.02			
In general, would you say that your health is?	Excellent	1	0.83	.		0.424	0.790
	Very Good	8	0.84	0.10			
	Good	26	0.92	0.30			
	Acceptable	9	0.81	0.06			
	Bad	6	0.89	0.16			

**Significant at P ≤ 0.05; NS-Not significant; N: number of subjects; SD: standard deviation; F: One way ANOVA & t: independent t test.*

Session frequency

Fifty-four and 46% of the participants were treated 2–3 times per week of dialysis. There was no association of Kt/V with session frequency (P = 0.652) (**Table 7**).

Table 7. association of dialysis session level (Kt/v) with dialysis and treatment variables.

Variables	Categories	KtV			Statistical Analysis		
		Count	Mean	SD	t	F	P-value
Number of chronic diseases:	0	4	0.83	0.00		0.157	0.959
	1	17	0.91	0.28			
	2	17	0.88	0.27			
	3	10	0.86	0.13			
	4	2	0.83	0.00			
Dialysis duration (months):	12 or less	11	0.82	0.04		1.750	0.156
	13-24	15	0.82	0.05			
	25-36	4	0.83	0.00			
	37-48	5	0.88	0.10			
	More than 48	15	1.01	0.39			
Number of dialysis sessions per week:	2	27	0.87	0.22	-0.454		0.652
	3	23	0.90	0.25			
The number of medicines you take daily	2 or less	5	0.84	0.01		0.808	0.496
	3-5	22	0.88	0.24			
	6-10	17	0.85	0.12			
	More than 10	6	1.01	0.45			

**P≤0.05; P>0 05: Not significant; N: Number of subjects; SD: Standard Deviation; F: one-way ANOVA & t: independent t' test.*

Summary Results

Demographics: The study group was equally represented across both genders and had a mean age of 55.06 years.

Adequacy of Dialysis: The percentage of patients with Kt/V <1.2 was 6% and that of URR <65% was 10% in spite of significant postdialysis reduction in weight and urea (P=0.000).

BMI & Lab Values: BMI was a significant predictor of URR (P = 0.004) with the best outcomes observed among underweight and obese patients. Albumin levels were also associated with adequacy (P=0.018). Hypoalbuminemia occurred in 72%, and 70% had moderate malnutrition.

Frequency of sessions 54% of patients were treated with only two sessions per week, which was below the recommended World Health Organization standards.

Infection and Co-morbidity: Infection was low (4%) and chronic diseases had no influence on adequacy.

DISCUSSION

The aim of this study was to investigate demographic, clinical, biochemical determinants of dialysis adequacy assessed by Kt/V in patients who were maintained by hemodialysis. Results: All factors except urea reduction ratio (URR) failed to significantly influence Kt/V values.

The between gender variations in the adequacy of dialysis were not significant in our study (P = 0.201), but the mean Kt/V for females (0.89 ± 0.22) was marginally better than that of males (0.80 ± 0.25). This is in line with the multicenter study by Pei et al. (2022), who noted marginal differences in dialysis outcomes based on gender when controlling for body surface area and vascular access quality.

The role of age and Kt/V levels was comparable, since the relationship between age and Kt/V levels was not significant (P = 0.153). Adequacy (Kt/V = 0.99) of patients aged ≤50 years was slightly higher but was not statistically significant. Previous studies indicated that younger patients are more likely to gain better dialysis outcomes because of fewer comorbidity and better vascular access (Xu et al., 2020).

BMI grade was not associated with Kt/V (P = 0.124). Notably, obese patients in this series had the greatest Kt/V (1.06), even though one would expect that increased BMI makes dialysis dosing more challenging. These findings are consistent with the recent study of Agarwal et al. (2022), who stress that patient-specific dialysis prescriptions have alleviated BMI-related inequalities in dialysis adequacy.

Dialysis volume (individualised prescription <3 L, 3 L or higher) did not have significant impact in Kt/V (P = 0.218), in line with the increasing belief that session length and blood flow rates are more important (Wang et al., 2021).

Laboratory measurements, such as calcium (P = 0.424), phosphate (P = 0.743), and albumin levels (P = 0.161) showed no significant association with Kt/V.17 However, patients with albumin levels of above 4.0 g/dL had higher mean Kt/V, implying a possible relationship between better nutritional status and better dialysis effectiveness, as evidenced previously (Rhee et al., 2023).

Infection status (P = 0.753) and anemia treatment (P = 0.470) did not significantly correlate with Kt/V in this population. But it is acknowledged that central venous catheters and uncontrolled anemia can influence long-term dialysis results (Kim et al., 2022).

The strongest explanation was the high correlation between Kt/V and URR groups (P = 0.000) and 65% good dialysis adequacy showed the highest Kt/v (1.28). This is consistent with the present clinical guidelines advice to use both Kt/V and URR as supplementary indices of dialysis adequacy (Kanda et al., 2019).

Finally, there were no significant differences in Kt/V values among nutritional status categories (P = 0.882). Although Kt/V was slightly lower than that in non-severe malnutrition patients, an integrated approach to nutrition management is essential for the appropriate management of dialysis patients (Yoo et al., 2022).

CONCLUSION

There is marked variation in dialysis efficacy at Nasser Medical Complex that this study demonstrates. Management addressing poor nutrition, the enhancement of dialysis targets, and more frequent sessions is encouraged to improve patient prognosis.

A. Summary of key findings

The sample appears to be representative of both male and female patients and the mean patient age was 55.06 years. In spite of regular dialysis treatments, only 6% of patients reached the recommended session adequacy goal (Kt/V ≥1.2) and only 10% improved for URR (≥65%). There were statistically significant reductions in weight and blood urea nitrogen after-dialysis (P=0.000), indicating effective fluid removal but inadequate clearance of the toxins in most patients.

B. Strategies to Enhance Dialysis Efficiency

Deviations from optimal RKF preservation would likely require a systems-level, multi-pronged approach:

Personal Dialysis Prescription

Personalized prescriptions for body size, residual kidney function, and comorbidities can make a substantial contribution to adequacy of dialysis. For instance to tailor session duration and dialyzer surface area to body surface area has been demonstrated to improve clinical outcomes (Pei et al., 2022; Kanda et al., 2019).

Nutritional Support

The lack of nutrients has detrimental effects on tissue perfusion and could diminish the efficacy of dialysis. Advocacy of interventions, such as intradialytic parenteral nutrition and frequent monitoring of the serum albumin levels, to enhance patients' response to dialysis have been advocated (Rhee et al., 2023).

Verifying Frequency and Duration of Sessions

Guidelines from the National Kidney Foundation call for three times a week for at least four hours each session. Failure to follow this schedule have demonstrated more likely to die and have lower Kt/V (Wang et al., 2021). Compliance can be enhanced by addressing patient impedance to care–transportation, cost, and knowledge.

Access Type Optimization

AVFs offer superior dialysis clearance to central venous catheters (Kim et al., 2022). The promotion of AVF use and the anticipation of creating an access early are important targets for quality improvement.

Staff Training and Uniformity

Use of checklists and nurse training, and real-time Kt/V monitoring software could help standardize care and minimize variation in treatment adequacy (Agarwal et al., 2022).

C. Suggestive Direction for More Research

Whereas, this study sheds light on a variety of clinical aspects, further investigations are necessary to deepen into aspects that have been less explored:

Quality of Dialysis Water and Reuse of Machines

The quality of dialysis water and routine maintenance of machines are important for safe and efficient dialysis. Impurities in dialysis water (e.g. endotoxins, chloramine) may also serve as triggers for inflammatory responses that compromise the effectiveness of dialysis therapies and contribute to long-term morbidity (Eaton et al., 2020). Few studies so far have addressed the direct effect of dialysate water quality systems on Kt/V and URR, and this is an issue that deserves further investigation.

Longitudinal Assessment of Nutritional Interventions

Future investigations should evaluate whether chronic dietary interventions will also lead to a reduction of Kt/V as well as for hospitalization rates, QoL, and death.

Intradialytic Exercise Programs

Recent evidence indicates that intradialytic physical activity may enhance solute clearance. Randomized trials could help determine optimal exercise modalities and frequencies (Majchrzak et al., 2023).

Recent data suggest that active movement during dialysis could improve the removal of small solutes. Randomized trials may be needed to establish optimal exercise modalities and frequency of training (Majchrzak et al., 2023).

Prediction of inadequate dialysis with ML-based models

Modeling yield prediction may be beneficial for clinicians to recognize not adequate dialysis session and to intervene in real time based on patient-specific data (Boulware et al., 2021).

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Competing interests

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Availability of data and materials

The materials described in the study are available from the corresponding author upon reasonable request.

Author contributions

Conception and design: AF, Provision of study materials: AF; Literature review: AF, Data analysis: AF, Manuscript writing: AF, Final approval of manuscript: AF. Author have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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