Dialysis Efficacy in End-Stage Renal Disease: The Interplay of Obesity, Age, Dialysis Duration, and Psychological Disturbance — A Correlational Cross-Sectional Study

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Abstract

Background: Dialysis efficacy is a critical determinant of survival and quality of life in patients with end-stage renal disease (ESRD). However, multiple patient-related factors—such as obesity, age, duration of dialysis, and psychological disturbance—may influence treatment outcomes. Understanding the interplay between these factors and dialysis effectiveness can help inform more personalized and holistic care strategies.

Objective: To investigate the relationship between dialysis efficacy and four key variables: obesity, age, dialysis duration, and psychological disturbance in patients undergoing maintenance hemodialysis.

Methods: A cross-sectional study was conducted among adult ESRD patients receiving regular hemodialysis. Dialysis efficacy was measured using Kt/V and urea reduction ratio (URR). Obesity was assessed by body mass index (BMI). Psychological disturbance was evaluated using validated scales including the Perceived Stress Scale (PSS-10). Correlation and multivariate regression analyses were performed to examine the association between the studied variables and dialysis efficacy.

Results: All significant predictors of dialysis efficacy (age, duration of dialysis, and psychological stress) identified at univariate analysis were entered a multivariate linear regression model together. This analysis identified that only duration of dialysis is a significant predictor.

Conclusions: Patient-specific characteristics (age, BMI, duration of dialysis, and psychological stress) can play an effect on dialysis adequacy especially duration of dialysis. Ongoing research is needed to delineate further effect of patient-specific characteristics on dialysis adequacy.

Keywords: hemodialysis; perceived stress; quality of life; end-stage renal disease; psychological distress; chronic kidney disease.

Introduction

Chronic renal failure is a condition that worsens with time resulting in permanent loss of renal function, causing the body to lose the ability to regulate and excrete fluid, electrolytes, and metabolic wastes, eventually leading to uremia (Javanbakhtian Ghahfarokhi R. et al. 2012). The most advanced stage of the disorder is referred to as end-stage kidney disease (dos Reis Santos I. et al. 2013). Prior to the middle of the 20th century, individuals suffering from kidney failure were idle patients without any treatment, awaiting their fate but not death. (Mottahedian-

Tabrizi E. et al. 2009). The aim of dialysis is to eliminate excess materials, stabilize the body's internal environment, and remove toxins that induce irreversible damage. (Tayyebi A. et al. 2012).
The cause of the disease, the use of alternative treatment modalities, the presence of comorbid conditions, especially cardiovascular disease, the adequacy of dialysis, and all other existing diseases significantly influence the patients' mortality diagnosed with end-stage kidney disease (Beladi M.S.S. et al. 2012). The quality of dialysis is a major fatality predictor among individuals receiving dialysis.Evidence indicates that increased effective hemodialysis treatment correlates with lower mortality in patients with kidney disorders (Abedi Samakoosh M. et al. 2013). Increased adequacy of hemodialysis will result in a reduction of complications from uremia and their sequelae on multiple systems. Hence, improved quality of hemodialysis treatment will benefit a multitude of organs in patients with chronic kidney failure. Improvements in these patients hemodialysis will address their psychosomatic problems (Shariati A. et al.,2012). The two most widely accepted methods for evaluating adequacy of dialysis are the KT/V (where K represents urea clearance, T denotes the time of dialysis, and V is the volume of urea) and the urea reduction ratio (URR) (Eshghizadeh M. et al., 2014).
As far as the desired and preferred methods of estimating quality of dialysis on the urea removal indicators of the KT/V and the URR is concerned, RPA and the NKF's DOQI reiterates that these indicators are preferred based on consensus recommendations.
It has been demonstrated in many studies that a KT/V of 1.2 or above or a URR of over 65%, has a positive impact on the outlook for dialysis patients (Moaveni et al. 2023). Nowadays, performing dialysis safely and within the appropriate parameters helps in the alleviation of complications. In addition, the reduction of frequent hospital admissions, the associated hospital cost savings, and remaining costs diverted to outpatient care greatly enhance the dialysis sufferers' standard of life (Mogharab et al. 2010).

Method

Design and Organization of the Experiment

This cross-sectional observational study was executed out from April 2024 to April 2025 in the nephrology unit of Haya Hospital, a public tertiary care center situated in Egypt. The center provides complete renal care services such as performing scheduled outpatient hemodialysis.
Hemodialysis sessions at this center are scheduled on Saturdays, Mondays, and Wednesdays, during which an average of 6 to 12 patients are treated per day.

Participant Eligibility

Inclusion criteria are:
- Adults aged ≥18 years.
- Identified as having ESRD and receiving hemodialysis therapy for a minimum of three months.
- Ability to give informed consent approved by the Faculty of Physical Therapy, Sinia University.

Exclusion criteria:
- Recent hospitalization or acute illness (<1 month).
- Cognitive, speech, or hearing impairments that could interfere with questionnaire administration.
- Psychiatric illness, or unwillingness to provide consent.

Data Collection Procedures

- Before full implementation, the instruments were piloted on 5% of the target population to refine procedures and address any ambiguity in item comprehension. Adjustments were made accordingly based on participant feedback.

Measurement Instruments

Dialysis Efficacy

- Measured using Kt/V and urea reduction ratio (URR) from routine dialysis records.

Independent Variables

Obesity:

- Measured using BMI (weight/height^2), categorized using WHO criteria (normal, overweight, obese).

Age:

- Recorded in years and analyzed as both a continuous and categorical variable (e.g.,<50, 50–65,>65).

Dialysis Duration:

- Total duration on hemodialysis in months.

Psychological Disturbance:

Perceived Stress Scale (PSS-10): This validated 10-item self-report tool evaluates how stressful people think certain situations in life are. Total scores range from 0 to 40 and were categorized as follows: 0 = no symptoms; 1–13 = mild stress; 14–26 = moderate stress;>26 = severe stress.
Short Form 36 for Kidney Disease Quality of Life (KDQOL-SFTM) 36 items make up the questionnaire, which describes how people have perceived their health over the past four weeks. These items include symptoms and issues, the kidney disease's impact, renal disease's effects on day-to-day living, employment status, cognitive abilities, The extent of conversations, sex performance, sleep patterns, and interpersonal interaction with dialysis staff, encouragement from dialysis personnel, patient contentment, role-physical, pain, physical functioning,

overall health, role-emotional, interpersonal performance, and energy/fatigue. The patient's history details, including gender, income, education, daily medication intake, etc., were also provided. The scoring guidelines found in the KDQOL-SFTM user manual were adhered to.A 0-100 scale was created from the pre-coded components, where an improved score indicated a higher quality of life ***(*****Hays RD** ***et al.,*** **1997*****)*.**

Statistical analysis

SPSS Version 27 statistical software package (SPSS Inc, Chicago, IL, USA) was used for all analyses. Data were presented as mean±SD and count (%) for continuous and categorical variables, respectively. Univariate linear regression analysis was performed for the dependent variable (dialysis efficacy) with each independent variable (age, BMI, duration of dialysis, and psychological disturbance) separately to identify the significant (p-value<2) predictor. This p-value was chosen so as not to lose any predictor at an early step. Finally, all independent variables which were significant at univariate analyses were analyzed in a multivariate regression model.

Results

This study included 84 hemodialysis patients of both sexes and their features are summarized in Table 1.

Table 1: Baseline Characteristics of all Patients

Variables	**Mean±SD**
Age (years)	55.33±12
BMI (kg/m$^{2)}$	29.8±5.25
Gender, n (%)	
Male	54 (64.3)
Female	30 (35.7)
Duration of dialysis, n (%)	
0-1 years	17 (20.2)
1-3 years	18 (21.4)
3-5 years	12 (14.3)
>5 years	37 (44)
Psychological stress scores	16.6±4.6
Dialysis efficacy (%)	74.2±7.4

SD: Standard deviation, n: Number

Univariate analysis:

Univariate regression analysis was performed for the dependent variable (dialysis efficacy) with each independent variable (age, BMI, duration of dialysis, and psychological stress) separately to identify the significant (p-value<2) predictor. This analysis showed that age, duration of dialysis, and psychological stress are significant (p<0.2) individual predictors of dialysis efficacy as shown in table (2).

Table (2): Univariate regression analysis for predictors of dialysis efficacy

Predictors	**B**	**Sig.**
Age	-0.1	**0.15**
BMI	-.007	0.97
Duration of dialysis	-1.2	**0.08**
Psychological Stress	-0.25	**0.19**

BMI: Body mass index, significant p<2 was bolded.

Multivariate regression analysis:

All significant predictors of dialysis efficacy (age, duration of dialysis, and psychological stress) identified at univariate analysis were entered a multivariate linear regression model together. This analysis identified that only duration of dialysis is a significant predictor. **(**Table 3).

Table (3): Multivariate regression analysis for independent predictors of dialysis efficacy

Model	**B**	**SE**	**Beta**	**t**	**Sig.**	**95% CI for B**	
						Lower	**Upper**
Constant	89.92	6.84		13.157	.000	76.31	103.53
Age	-.113	.069	-.19	-1.648	.103	-.250	.024
Duration of dialysis	-1.53	.677	-.25	-2.261	**.027**	-2.88	-.183
Psychological Stress	-.214	.185	-.13	-1.156	.251	-.582	.154

BMI	-.054	.156	-.04	-.345	.731	-.365	.257

SE: Standard error, CI: Confidence interval, significant p<0.05 was bolded.
The equation of the multivariate regression can be written as:

Dialysis efficacy = 89.9 - 1.5 X Duration of dialysis+7
For example, when duration of dialysis increases one unit, dialysis efficacy changes/worsens 1.53%.
This model (with these independent predictors) explains about 10.5% of the change in dialysis efficacy(R squared=0.105) (p-value =0.07). (Table 4).

Table (4): Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.324	.105	.058	7.159

Discussion

The adequacy of dialysis directly impacts the survival and The standard of lifestyle for individuals receiving maintenance hemodialysis
(MHD).
This study focused on the influence of patient-specific characteristics (age, BMI, dialysis duration, and psychological stress) on the adequacy of dialysis.
Univariate regression analysis was conducted on the dependent variable (dialysis efficacy) for each independent variable (age, BMI, duration of dialysis, and psychological stress) in order to determine the significant predictor (p-value<2). Age, duration of dialysis, and psychological stress were significant (p<0.2) and all predictors of dialysis efficacy identified in the univariate analysis (age, duration of dialysis, and psychological stress) were collectively entered into a multivariate linear regression model. This analysis identified that only duration of dialysis remains a significant predictor.
Juan L. et al. have addressed a number of issues regarding the effectiveness of dialysis for MHD patients, such as patient-specific traits and dialysis equipment.
The study conducted by Jia, W., et al also supports this, where he states that dialysis adequacy is significantly influenced by date of birth, gender, dry kilograms, and length of dialysis for MHD patients. Among those factors, duration of dialysis and dry weight were found to be independent factors determining dialysis adequacy.
Nasri et al, described the association adverse correlation of age with dialysis adequacy by creatinine observing in patients younger and older than 50 years, where the older patients had lower values.
Al Raii et al. demonstrated that the ability of hemodialysis to clear creatinine from the blood of obese patients is also mitigated. Obesity also decreases the efficiency of dialysis in removing urea, potassium, and sodium, as seen in the obese women from the study. Furthermore, obese patients had elevated levels of the parathyroid hormone, which governs the concentration of calcium and phosphates in the blood. This is concerning, as phosphates are one of the key markers in tracking the progression of chronic renal failure. Hence, it can be concluded that obesity and the complications of renal failure concurrently advance. Overall, our findings confirm that obesity compromises the efficiency of dialysis in patients with chronic kidney disease. These findings are also supported by Hong and Leer. Obesity, as measured by BMI, modifies the impact of dialysis adequacy on mortality within the maintenance hemodialysis cohort.
Survival in patients on maintenance hemodialysis (MHD) has been linked to adequacy of dialysis. In contrast, it has been posited that psychiatric comorbidity increases the mortality and morbidity of MHD patients. A number of studies indicate that the adequacy of hemodialysis is inversely related to the burden of depression and anxiety. An instance of this is Hung et al.
A study of 146 patients revealed a weak association (r = 0.2) between depression and Kt/V. Kt/V measures the adequacy of dialysis. Kt/V measures the adequacy of dialysis. Klaric and Klaric reported a relationship between depression and dialysis adequacy to patients receiving peritoneal dialysis but not MHD patients. They speculate these findings may arise from uniform distribution of Kt/V in MHD patients. Montinaro et al. found no differences in Kt/V means between depressed, anxious, and normal patients. Similar to this study, Montinaro et al. found no association between depression and anxiety with dialysis adequacy. Shojaat et al. confirmed the adequacy of dialysis in patients undergoing hemodialysis treatment is not affected by mental disorders, such as anxiety and depression. Najafi A et al. showed that depression and anxiety are common among hemodialysis patients and also found no significant correlation between anxiety and depression and the adequacy of dialysis.
Guangmin H et al. study contradicts these findings. They found patients in the adequate dialysis group had longer dialysis durations. Prolonged exposure to toxins and accumulation of β2-microglobulin is straining. High level of β2-microglobulin is indicative of middle-molecule substances that are in need of clearance, and low clearance is ∝ to the presence of β2-microglobulin. β2-microglobulin is a dynamically metabolized product. This means there is a constant need to metabolize β2-microglobulin.

A single measurement is influenced by production rate, distribution volume, residual renal function, etc., and cannot be considered equivalent to the toxin burden. Thus, the accumulation of β2-microglobulin indicates a need for an adjustment to the dialysis regimen, but not for the prognosis.

Conclusions

patient-specific characteristics (age, BMI, duration of dialysis, and psychological stress) can play an effect on dialysis adequacy especially duration of dialysis. Ongoing research is needed to delineate further effect of patient-specific characteristics on dialysis adequacy.

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