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The relation of residual kidney function to post-dialysis fatigue

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Abstract

Hemodialysis is used to treat more than 2 million people with chronic kidney disease (CKD) worldwide. Even after dialysis is started, residual kidney function (RKF) is still crucial for the health and happiness of individuals with end-stage kidney disease (ESKD). In addition to being crucial for maintaining fluid homeostasis, RKF may also regulate mineral metabolism, inhibit the inflammatory response, and enhance the removal of dangerous intermediate molecules and protein-bound uremic toxins. Dialysis patients frequently experience fatigue, which is linked to a lower health-related quality of life (HRQOL). This study aimed to assess post dialysis fatigue and its relation to residual kidney function. Patients and Methods: Seventy patients undergoing maintenance hemodialysis using high-flux dialyzer were enrolled in this Pilot comparative cross-sectional study at Nephrology Department, Haemodialysis unit, Ain shams university Hospital in the period from January 2023 to July 2023.70 study participants, with mean age 48.29 ± 11.77 years, were enrolled in the study. Group (A) Consisted of (35) ESKD patients with residual kidney function (24-hour urine volume ≥ 100 ml), Group (B) Consisted of (35) ESKD patients without residual kidney function. The FAS score had a median value of 27 (IQR 24 - 31) among all patients. 12 patients (17.1%) experienced no fatigue, 47 patients (67.1%) reported fatigue, and 11 patients (15.7%) described extreme fatigue. FAS scores reported higher fatigue levels in females (mean 28.97 ± 4.73, p value 0.034). There was no statistically significant difference in FAS scores between the two groups, however; there was significant differences between both groups as regard age (mean 43.77 ± 12.4 in group A versus 52.8 ± 9.24 in group B), dialysis vintage (median 14 (11- 24) months in group A versus 108 (50 - 168) months in group B) and there is a significant negative correlation between RKF and Urea post (r = -0.374, p = 0.027). This research brings into focus the elaborate correlation between RKF and fatigue, underscoring the diverse aspects of symptomatology in ESKD. RKF has no significant impact on post dialysis fatigue. RKF tends to decrease with longer number of years on hemodialysis. Urea post is the only well documented factor inversely correlated with the RKF.

Keywords: Fatigue Assessment Scale, Residual kidney function, end-stage kidney disease.

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1. Introduction

Both the annual cost and the number of patients getting hemodialysis (HD) and peritoneal dialysis (PD) are rising [1]. There is no agreed-upon definition of RKF. The recommendations recommend assessing RKF for both PD and HD patients by taking the mean of the 24-hour creatinine clearance and urea clearance; however, there are still a lot of confounding factors to consider. Therefore, although the clearance of iohexol, ethylenediaminetetraacetic acid, iothalamate, and inulin is considered a superior way to quantify GFR, it is not appropriate for use in clinical practice. The glomerulus should filter ideal RKF indicators rather than the tubules secreting them and clearing them into the urine with the added risk of passing through HD or PD membranes. Middle molecular weight proteins, including beta2-microglobulin (β2M), cystatin C, and beta-trace protein (βTP), have been shown in recent studies to have a strong correlation with measured GFR. As a result, these proteins have been suggested as novel GFR indicators [2].

Dialysis patients frequently experience fatigue, which is linked to a lower HRQOL. Most hemodialysis patients feel lethargic and fatigued after their sessions. It is common for patients to relax or take a sleep within five hours following dialysis, and over 80% of them report feeling tired [3].

The pathophysiology of post-dialysis fatigue (PDF) is thought to be caused by inflammation, dysregulation of the hypothalamic-pituitary-adrenal axis, and variations in osmotic and fluid levels. However, none of these theories have been proven to be true or consistently supported by evidence yet. The prevalence of PDF varies from 20% to 86%. Several clinical variables, including as depression,

physical inactivity, aberrant lab results, and the cardiovascular and hemodynamic consequences of dialysis, are linked to PDF [4]. This study aimed to assess post dialysis fatigue and its relation to residual kidney function.

2. Patients and methods

This Pilot Comparative Cross-Sectional Study included 70 adult patients with kidney failure treated with maintenance hemodialysis (MHD) 3 times a week for at least 3 months at Nephrology Department, Haemodialysis Unit; Ain Shams University Hospital in the period from January 2023 to July 2023. Patients were considered eligible if they (a) were above the age of 18 years, (b) had a well-functioning arteriovenous fistula or arteriovenous graft capable of supplying a blood flow rate of 300ml/min (C) Haemoglobin 10 gm/dl or more. The exclusion criteria were Age above 65 years, Diagnosis of collagen diseases, rheumatological disorders, psychiatric diseases Patients on immunosuppressive drugs, dementia, severe chronic illness, or active cancer. Patients were allocated into two groups:

Group (A) Consisted of (35) ESKD patients with residual kidney function (24-hour urine volume ≥ 100 ml).

Group (B) Consisted of (35) ESKD patients without residual kidney function. All patients underwent conventional 4-hour bicarbonate HD 3 times a week using high-flux membranes. Blood flow ranged from 250 to 300 ml/min, with a dialysis rate flow of 500 ml/min. Recorded parameters at study inclusion included age, gender, weight, height, HD regimen, and comorbid conditions.

2.1: Fatigue Assessment Scale (FAS)

2.1.1: Definition of Fatigue

Fatigue was characterized as exhaustion, distaste of current activity, and unwillingness to continue, indicating a drop in vigilance and lower capacity to perform.

2.1.2: Significance of FAS

The FAS is a validated questionnaire available in multiple languages, facilitating quick and easy assessment of fatigue in patients with chronic diseases, including those under hemodialysis. FAS Structure: FAS comprises 10 questions, with five focusing on physical fatigue and five on mental fatigue.

2.2: Scoring

Responses are required for all questions. Scores for questions 4 and 10 should be recoded (1=5, 2=4, 3=3, 4=2, 5=1). The total FAS score, ranging from 10 to 50, is calculated by summing all question scores (including recoded scores for questions 4 and 10). A total score < 22 indicates no fatigue, while a score ≥ 22 indicates fatigue.

2.3: Categories

FAS scores can be categorized as follows: FAS scores 10 - 21: no fatigue (normal), FAS scores 22 – 50: Substantial fatigue, Fatigue: scores 22-34 and extreme fatigue: scores ≥ 35 [5].

3. Biochemical analyses

Various blood samples were collected before the mid-week session for analysis, including hemoglobin, serum creatinine, serum albumin, serum calcium, serum phosphorus, parathyroid hormone (PTH), C-reactive protein (CRP), serum urea pre- and post-hemodialysis to calculate urea reduction ratio (URR), and serum ferritin. 24-hour Urine Sample: A 24-hour urine sample was collected before the session to calculate urinary creatinine clearance.

4. Discussion

Patients with kidney disease frequently experience fatigue, which affects both a sizable fraction of ESKD patients getting hemodialysis and those who are not. According to reports, 60–97% of ESKD patients receiving hemodialysis and up to 69% of patients with CKD who are not receiving dialysis report feeling fatigued [6]. Post-dialysis fatigue (PDF) is a common and debilitating condition experienced by HD patients. It is characterized by persistent feelings of exhaustion and lack of energy following each dialysis session. This condition significantly impairs dialysis patients' health related QOL, leading to poor physical and mental well-being [7].

The term "residual kidney function" (RKF) describes the kidneys' capacity to filter and eliminate waste materials even after dialysis is started, as well as its residual function following damage from CKD. In the context of dialysis patients, the relationship between RKF and post-dialysis weariness is of great interest. Several research works have demonstrated the significance of RKF in raising survival rates, boosting QOL, and offering extra solute clearance to patients receiving different types of dialysis [8]. The median FAS score was 27, the range of FAS scores was between 16-37, which indicated a wide variation in fatigue levels among the patients. In addition, the analysis showed that 12 (17.1%) of the patients had no fatigue, 47 (67.1%) had fatigue, and 11 (15.7%) had extreme fatigue. Similarly, **Zyga et al. [9]** assessed fatigue in 129 ESKD patients undergoing HD using the FAS score. The mean FAS score was 24.99, with 49 patients (38.0%) being non-fatigued, 61 patients (47.3%) being fatigued, and 19 patients (13.7%) being highly fatigued.

In contrast to our findings, **Suparti et al. [10]** conducted a study, to ascertain the relationship between the degree of fatigue experienced by 75 ESRD patients receiving hemodialysis and the adequacy of their hemodialysis. The findings revealed that 81.23% of patients received adequate dialysis, with 62 (82.7%) of the respondents reporting severe fatigue. Most patients did not meet their dialysis adequacy objectives, which may explain the difference in results between our study and Suparti's. The Suparti study's average dialysis adequacy score was 1.42.

In the current study, the mean age was higher in patients without RKF than those with RKF, P-value= 0.001. In addition, Dialysis vintage was highly significant in patients without RKF than those with RKF (median 14 (11-24) months in patients with RKF versus 108 (50 – 168) in patients without RKF) and P-value< 0.001. Table (1).

This result is in line with the research conducted by **Obi et al. [11]** on a sizable longitudinal cohort of 6538 patients who began maintenance HD over a 4-year period. Their objectives were to identify the clinical factors at the time of hemodialysis initiation that predicted preserved RKF at one year and to quantitatively investigate the relationship between the annual change in RKF and survival. The connection of yearly change in renal CL_{urea} rate with eventual survival was investigated in patients having

accessible renal urea clearance (CL_{urea}) data at baseline and 1 year after hemodialysis beginning. CL_{urea} median (interquartile range) baseline value and mean±SD yearly change were 3.3 (1.9-5.0) and -1.1±2.8 ml/min per 1.73m2, respectively. RKF reduction throughout the first year of dialysis revealed a graded connection with all-cause mortality among incident HD patients.

In our study, there was no statistically significant variation in demographic variables between the two analyzed groups, including gender, weight, height, BMI, diabetes, hypertension, and hepatitis Status. Table (1). Also, there was no significant changes between the two study groups according to laboratory parameters included hemoglobin, ferritin, serum albumin, calcium, phosphorus, Ca*Po4 product, PTH, CRP, urea pre, urea post, urea reduction rate% (URR%), and serum creatinine. Table (2).

When categorizing fatigue levels, it's noteworthy that patients with no RKF had a higher percentage of patients experiencing fatigue and extreme fatigue compared to patients with RKF, despite the fact that this difference was not statistically significant (NS). Moreover, no statistically significant correlation was found between the FAS score and RKF in the present study, P-value= 0.726. Table (3). On the contrary, RKF was significantly associated with urea post-hemodialysis session, P-value= 0.027. The relation was inversely direction, r= -0.374. These results suggested that RKF plays a significant role in the outcomes of HD patients; RKF preservation is related with improved patient outcomes.

In contrast, **Elgendy et al. [12]** conducted a study, 78 adult (age > 18) ESRD patients undergoing regular HD for more than 6 months had a significantly higher score for KDQOL-SF version 1.3 for assessing QOL and Montreal cognitive assessment score for assessing cognitive function domains in patients with RKF (n = 29) who pass 100 ml/day of urine compared to patients without RKF (n = 49). This contradiction may be due to various methods of measuring RKF. In our study, blood samples for measuring blood urea nitrogen (BUN) were obtained at the conclusion of the first dialysis session of the week (BUN 1) and immediately before the following session (BUN 2). Urine was collected throughout the interdialytic time (44-hour urine collection) between these blood samples, and residual renal function was calculated using this equation (interdialytic urine volume x urine urea concentration / interdialytic duration / mean BUN). Where (BUN 1 + BUN2)/2 is the mean BUN.

The literature on the connections between RKF and outcomes, particularly in the HD population, was compiled by **Kong et al. [13]** from a search of the Ovid MEDLINE and EMBASE databases conducted between August 15, 2017, and March 1, 2018. A total of 650 publications were found. When dialysis is started, more than 80% of patients have some degree of RKF. Although this decreases with time, up to 30% of people on HD for five years still maintain detectable levels of native kidney function. Additionally, HD patients who had urine output at baseline also reported higher overall QOL (P = 0.05), according to a validated patient feedback form.

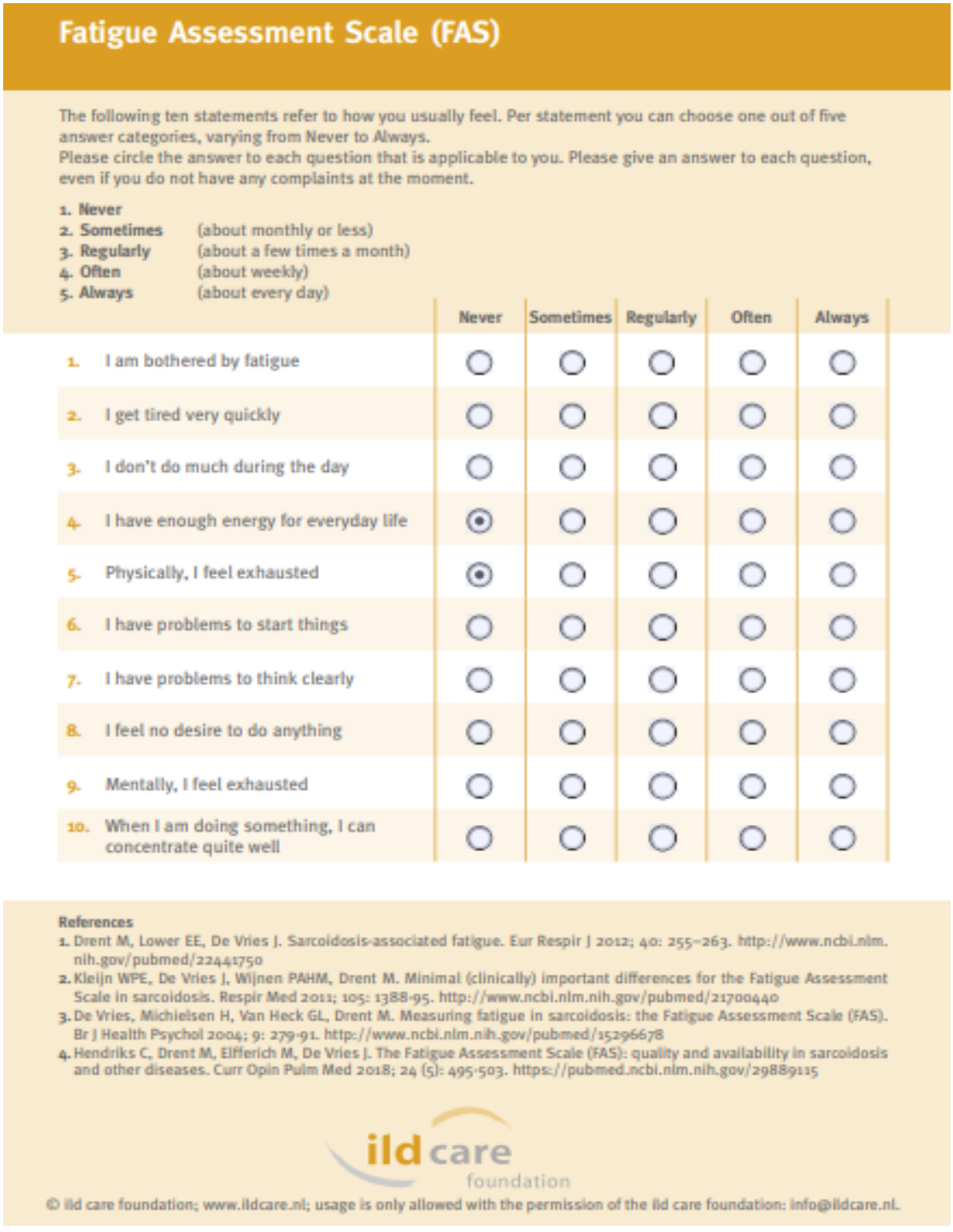
Another study by **De Sequera et al. [14]** discovered in another investigation that there was a correlation between lower levels of inflammatory markers and increased RKF. C-reactive protein (CRP) concentrations were lower in patients with residual renal urea clearance (KrU >1 mL/min and diuresis >100 mL/day) (6.2 vs. 21.4 mg/L, P = 0.038).

Also, study by **Vilar et al. [15]** who found 650 patients who began HD treatment at the Lister Renal Unit during a 15-year period from 1989 to 2005, they found the correlation between residual renal function and many HD patient outcome indicators. At 6, 36, 48, and 60 months following the start of dialysis, there was no discernible change in serum haemoglobin between participants with a renal urea clearance KRU_{BSA} above or below 1 ml/min. Nonetheless, individuals with KrU ≥ 1 mL/min per 1.73 m^2 had a lowered weekly EPO (erythropoietin) dose and a reduced EPO resistance index for as long as 48 months from the start of HD.

Kong et al. [16] collected medical record data from all 90 HD patients who were treated by Austin Health and were older than 18 years, From October 1, 2017, to May 1, 2018. A timed interdialytic urine sample was used to measure RKF in between each week's first and second dialysis sessions. An RKF value of 0 mL/min/1.73 m2 was assigned to patients whose self-reported urine output during the interdialytic interval was more than 200 mL. The palliative care outcome scale symptom questionnaire, which has been adapted for use in patients with renal failure, was used to quantify the patients' symptoms. Higher renal urea clearance levels were substantially linked (P <0.0001) with longer HD treatment durations. The KRU level was unrelated to haemoglobin, phosphate, albumin, parathyroid hormone, and CRP. Individuals with a KRU of ≥1 mL/min/1.73 m^2 reported less uremic symptoms (5.3±3.5 vs. 7.7±3.8, P = 0.014) than those with a KRU of <1 mL/min/1.73 m^2. RKF may have an influence on these patients' symptom load, as seen by the 80% of patients with weakness/lack of energy reported in KRU <1 mL/min/1.73 m^2 compared to 58% in patients with KRU ≥1 mL/min/1.73 m^2.

No statistically significant association was detected between the fatigue and other laboratory parameters. We can hypothesize that the serum levels of haemoglobin, creatinine, urea, albumin, PTH, and the URR% in the study population were relatively homogeneous because all patients received erythropoietin to maintain haemoglobin levels between 11 g/L and 12 g/L and were treated to target PTH and other laboratory parameters according to the KDOQI guidelines. Table (4). In addition, the current study detected a statistically significant association between FAS score and gender. FAS score was higher in females (28.97 ± 4.73) than males (26.19 ± 5.88), P-value= 0.034. Table (5)

The goal of **Bossola et al. [17]** study was to evaluate the connection between fatigue qualities (FQ) and other features of 68 chronic HD patients. The research findings indicate that several laboratory variables, including serum albumin, creatinine, urea, HD, PTH levels, and Kt/V, did not exhibit any significant correlation with the different tiredness qualities or the quantity of FQ.



Fatigue Assessment Scale (FAS)

The following ten statements refer to how you usually feel. Per statement you can choose one out of five answer categories, varying from Never to Always.
Please circle the answer to each question that is applicable to you. Please give an answer to each question, even if you do not have any complaints at the moment.

1. **Never**
2. **Sometimes** (about monthly or less)
3. **Regularly** (about a few times a month)
4. **Often** (about weekly)
5. **Always** (about every day)

	Never	Sometimes	Regularly	Often	Always
1. I am bothered by fatigue	○	○	○	○	○
2. I get tired very quickly	○	○	○	○	○
3. I don't do much during the day	○	○	○	○	○
4. I have enough energy for everyday life	◉	○	○	○	○
5. Physically, I feel exhausted	◉	○	○	○	○
6. I have problems to start things	○	○	○	○	○
7. I have problems to think clearly	○	○	○	○	○
8. I feel no desire to do anything	○	○	○	○	○
9. Mentally, I feel exhausted	○	○	○	○	○
10. When I am doing something, I can concentrate quite well	○	○	○	○	○

References
1. Drent M, Lower EE, De Vries J. Sarcoidosis-associated fatigue. Eur Respir J 2012; 40: 255–263. http://www.ncbi.nlm.nih.gov/pubmed/22441750
2. Kleijn WPE, De Vries J, Wijnen PAHM, Drent M. Minimal (clinically) important differences for the Fatigue Assessment Scale in sarcoidosis. Respir Med 2011; 105: 1388-95. http://www.ncbi.nlm.nih.gov/pubmed/21700440
3. De Vries, Michielsen H, Van Heck GL, Drent M. Measuring fatigue in sarcoidosis: the Fatigue Assessment Scale (FAS). Br J Health Psychol 2004; 9: 279-91. http://www.ncbi.nlm.nih.gov/pubmed/15296678
4. Hendriks C, Drent M, Elfferich M, De Vries J. The Fatigue Assessment Scale (FAS): quality and availability in sarcoidosis and other diseases. Curr Opin Pulm Med 2018; 24 (5): 495-503. https://pubmed.ncbi.nlm.nih.gov/29889115

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Figure 1: Fatigue Assessment Scale [5].

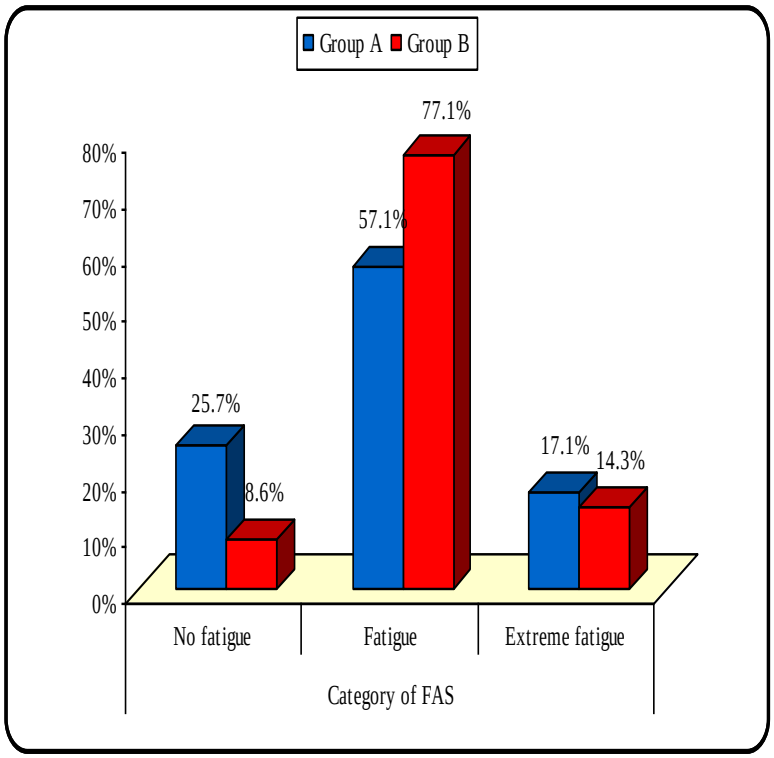

Figure (2): Comparison between group A and group B regarding FAS score and fatigue

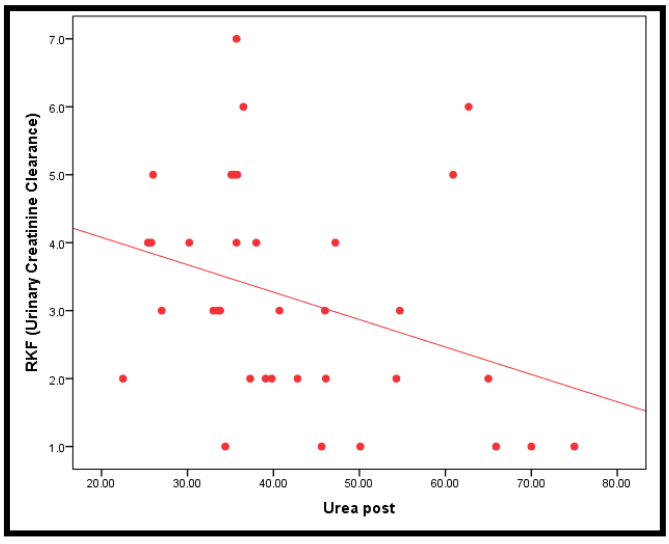

Figure 3: Correlation of RKF (Urinary Creatinine Clearance) with urea post dialysis.

Table 1: A detailed comparison of demographic and characteristic factors between two groups. It highlights significant differences in age and dialysis vintage.

		All patients No. = 70	**Group A (No 35)**	**Group B (No 35)**	**Test value**	**P-value**	**Sig.**
Age (year)	Mean ± SD	48.29 ± 11.77	43.77 ± 12.4	52.8 ± 9.24	-3.454•	**0.001**	HS
	Range	20 – 65	20 – 64	34 – 65			
Sex	Females	33 (47.1%)	17 (48.6%)	16 (45.7%)	0.057*	0.811	NS
	Males	37 (52.9%)	18 (51.4%)	19 (54.3%)			
Weight (kg)	Mean ± SD	71.25 ± 18.64	71.41 ± 19.25	71.09 ± 18.29	0.072•	0.943	NS
	Range	39.5 – 119.5	42 - 119.5	39.5 – 103			
Height (cm)	Mean ± SD	165.83 ± 7.34	166.06 ± 7.21	165.6 ± 7.57	0.259•	0.797	NS
	Range	150 – 188	152 – 182	150 – 188			
BMI (Kg/m2)	Mean ± SD	25.97 ± 6.67	26.08 ± 6.98	25.87 ± 6.44	0.135•	0.893	NS
	Range	15.4 – 42.5	15.4 - 42.5	16.4 - 37.8			
Dialysis vintage (Months)	Median (IQR)	36 (13 - 119)	14 (11-24)	108 (50 - 168)	-5.730‡	**0.001**	HS
	Range	6 – 298	6 – 240	6 – 298			
Diabetes mellitus	No	58 (82.9%)	26 (74.3%)	32 (91.4%)	3.621*	0.069	NS
	Yes	12 (17.1%)	9 (25.7%)	3 (8.6%)			
Hypertension (mmHg)	No	14 (20.0%)	4 (11.4%)	10 (28.6%)	3.214*	0.073	NS
	Yes	56 (80.0%)	31 (88.6%)	25 (71.4%)			
Cerebrovascular stroke	No	50 (71.4%)	27 (77.1%)	23 (65.7%)	1.120*	0.290	NS
	Yes	20 (28.6%)	8 (22.9%)	12 (34.3%)			
Hepatitis Status	Negative	39 (55.7%)	23 (65.7%)	16 (45.7%)	2.837*	0.092	NS
	Positive (HCV)	31 (44.3%)	12 (34.3%)	19 (54.3%)			

Table 2: Laboratory characteristics of the patients

Laboratory investigations		All patients No. = 70	Group A (No 35)	Group B (No 35)	Test value	P-value	Sig.
Hemoglobin (g/dL)	Mean ± SD	11.12 ± 1.27	11.03 ± 0.96	11.21 ± 1.52	-0.592•	0.556	NS
	Range	10 – 16.2	10 - 13.8	10 - 16.2			
Ferritin (ng/mL)	Median (IQR)	315 (117-610)	315 (117 - 610)	350 (160 - 910)	-0.529‡	0.597	NS
	Range	15 – 3348	15 – 3348	33.7 – 2540			
Serum albumin (g/dL)	Mean ± SD	3.89 ± 0.35	3.97 ± 0.34	3.81 ± 0.35	1.967•	0.053	NS
	Range	2.95 – 5	3.4 – 5	2.95 - 4.9			
Calcium (mg/dL)	Mean ± SD	8.76 ± 0.73	8.77 ± 0.75	8.75 ± 0.72	0.098•	0.922	NS
	Range	7.4 – 11	7.5 – 11	7.4 - 10.3			
Phosphorus (mg/dL)	Mean ± SD	4.60 ± 1.11	4.57 ± 1.18	4.62 ± 1.05	-0.193•	0.847	NS
	Range	2.5 – 9	3.2 – 9	2.5 - 6.5			
Ca*Po4 product (mg^2/dL^2)	Mean ± SD	40.30 ± 10.11	40.18 ± 10.69	40.43 ± 9.66	-0.101•	0.920	NS
	Range	20.75 – 76.5	28 - 76.5	20.75 - 63.7			
PTH (pg/mL)	Median (IQR)	336.5 (134.4 - 610)	370 (245.8 - 750)	534 (200.6 - 905.4)	-0.828‡	0.408	NS
	Range	15 – 3348	40 - 2075.5	69.7 – 2918			
CRP (mg/dL)	Mean ± SD	6.01 ± 1.91	6.29 ± 1.82	5.74 ± 1.98	1.194•	0.236	NS
	Range	3 – 10	3 – 10	3 – 10			
Urea pre (mg/dL)	Mean ± SD	115.71 ± 25.93	114.7 ± 25.4	116.73 ± 26.77	-0.325•	0.746	NS
	Range	54 – 176	54 - 173.2	72.2 – 176			
Urea post (mg/dL)	Mean ± SD	40.26 ± 13.99	42.49 ± 13.62	38.04 ± 14.19	1.337•	0.186	NS
	Range	14.5 – 76	22.5 – 75	14.5 – 76			
URR%	Mean ± SD	64.42 ± 12.90	62.68 ± 12.66	66.15 ± 13.08	-1.130•	0.262	NS
	Range	14.8 – 83.74	14.8 - 79.2	22.4 - 83.74			
Serum Creatinine (mg/dL)	Mean ± SD	7.31 ± 1.13	7.51 ± 1.46	7.11 ± 0.62	1.521•	0.133	NS
	Range	5.36 – 11.78	5.36 - 11.78	5.7 - 8.1			
RKF	Mean ± SD		3.17 ± 1.64 1 – 7				

Ca*Po4 product: Calcium-Phosphorus Product, PTH: Parathyroid Hormone, CRP: C-Reactive Protein, URR%: Urea Reduction Ratio

Table (2) reveals that there were no statistically significant differences between group A and group B in terms of various laboratory findings.

Table 3: FAS score of the studied patients

		All patients	Group A	Group B	Test value	P-value	Sig.
		No 70	No. = 35	No. = 35			
FAS score	Median (IQR)	27 (24 - 31)	26.71 ± 5.96	28.29 ± 4.98	-1.142‡	0.254	NS
	Range	16 – 37	16 – 37	16 – 37			
Category of FAS	No fatigue	12 (17.1%)	9 (25.7%)	3 (8.6%)	4.133*	0.127	NS
	Fatigue	47 (67.1%)	20 (57.1%)	27 (77.1%)			
	Extreme fatigue	11 (15.7%)	6 (17.1%)	5 (14.3%)			

Table (3) it's noteworthy that group B had a higher percentage of patients experiencing fatigue and extreme fatigue compared to group A.

Table 4: Correlation of FAS score with demographic data, laboratory finding

	FAS score	
	R	p-value
Age (year)	0.092	0.449
Weight (kg)	0.168	0.164
Height (cm)	0.101	0.407
BMI (Kg/m2)	0.165	0.172
Dialysis vintage (Months)	0.087	0.472
Hemoglobin	-0.079	0.514
Ferritin (ng/mL)	-0.100	0.408
Serum albumin (g/dL)	-0.012	0.919
Calcium (mg/dL)	-0.020	0.867
Phosphorus (mg/dL)	0.223	0.064
Ca*Po4 product (mg^2/dL^2)	0.216	0.072
PTH (pg/mL)	-0.02	0.87
CRP (mg/dL)	0.131	0.280
Urea pre (mg/dL)	0.124	0.307
Urea post (mg/dL)	0.034	0.781
URR%	-0.003	0.981
Serum Creatinine (mg/dL)	-0.143	0.238

Table (4) showed no significant correlation between FAS score and any demographic or laboratory data.

Table 5: Relation of FAS score with demographic data

		FAS score		Test value•	P-value	Sig.
		Mean ± SD	Range			
Sex	Females	28.97 ± 4.73	19 – 37	2.164	**0.034**	S
	Males	26.19 ± 5.88	16 – 37			
Diabetes	No	27.16 ± 5.43	16 – 37	1.154	0.252	NS
	Yes	29.17 ± 5.81	16 – 37			
Hypertension (mmHg)	No	25.0 ± 5.62	16 – 35	1.751	0.08	NS
	Yes	28.12 ± 5.35	16 – 37			
CVS	No	26.62 ± 5.51	16 – 37	1.896	0.058	NS
	Yes	29.7 ± 4.99	22 – 37			
Hepatitis Status	Negative	27.85 ± 5.43	16 – 37	0.587	0.559	NS
	Positive	27.06 ± 5.67	16 – 37			

Table (5) there was a statistically significant difference in FAS scores between males and females, with females reporting higher fatigue levels.

Table 6: Correlation of RKF (Urinary Creatinine Clearance) with demographic data, laboratory finding and FAS score

Group A	RKF (Urinary Creatinine Clearance)	
	R	p-value
FAS score	0.062	0.726
Age (year)	0.109	0.532
Weight (kg)	-0.249	0.150
Height (cm)	0.017	0.924
BMI (Kg/m2)	-0.243	0.16
Dialysis vintage (Months)	-0.219	0.205
Hemoglobin	0.143	0.414
Ferritin (ng/mL)	-0.105	0.549
Serum albumin (g/dL)	0.109	0.534
Calcium (mg/dL)	-0.011	0.951
Phosphorus (mg/dL)	0.059	0.735
Ca*Po4 product (mg^2/dL^2)	0.011	0.95
PTH (pg/mL)	-0.233	0.179
CRP (mg/dL)	-0.299	0.081
Urea pre (mg/dL)	-0.289	0.092
Urea post (mg/dL)	**-0.374***	**0.027**
URR%	0.155	0.375
Serum Creatinine (mg/dL)	-0.115	0.509

Table (6) there was a significant negative correlation between RKF and Urea post.

Table 7: Univariate linear regression analysis of urea post in relation to RKF

	Unstandardized Coefficients		Standardized Coefficients	T	P-value
	B	SE	Beta		
Urea post (mg/dL)	-0.040	0.020	-0.336	**-2.050**	**0.048**

Table (7) it was found that Urea post has a significant negative relationship with RKF.

Further, Arhamawati et al. [18] who found that of 30 patients with CKD, more male patients than female patients, the relationship between the levels of blood urea, creatinine, and haemoglobin and exhaustion was examined. The mean serum urea level was 158.09, the creatinine level was 12.00, the haemoglobin level was 8.19, and the fatigue score was 29.90. According to the study's findings, there was no correlation between fatigue and serum urea levels ($p = 0.928$; $\alpha = 0.05$), no correlation between fatigue and creatinine ($p = 0.863$; $\alpha = 0.05$), and a significant correlation between fatigue and haemoglobin ($p = 0.021$; $\alpha = 0.05$; $r = -0.419$) with a negative moderate correlation between the variables. The target hemoglobin level in Arhamawati et al. study differs from the current study where target hemoglobin maintained between 11 g/L and 12 g/L.
Univariate linear regression analysis of urea post in relation to RKF revealed that urea post was the most influential parameters affecting RKF. Tables (6 & 7).

4. Statistical analysis

SPSS V. 20.0 was utilized for statistical analysis. For continuous variables, the mean ± SD was shown for data that was regularly distributed, while the median and interquartile range were shown for data that was skewed. Categorical variables were represented by counts and percentages. For comparisons between groups, the independent-samples t-test was utilized. Associations between categorical variables were found using the chi-square test or, if suitable, Fisher's exact test. To find the relationships in the study, Pearson's correlation test was employed. The statistical significance level was established at two-sided p-values of <0.05.

5. Conclusions

This research brings into focus the elaborate correlation between RKF and fatigue, underscoring the diverse aspects of symptomatology in ESKD. RKF has no significant impact on post dialysis fatigue. RKF tends to decrease with longer number of years on hemodialysis. Urea post is the only well documented factor inversely correlated with the RKF.

6. Recommendations

Further investigations with larger sample sizes and additional inquiries are merited to gain a more comprehensive comprehension of the variables influencing fatigue and to formulate precise interventions aimed at enhancing the QOL for individuals with ESKD.

7. Limitations of the study

The sample size was limited, and the modelled regression equations were based on a population of laboratory parameters that were generally homogeneous when handled with a high flow dialyzer. Because this is a regularly used approach for RKF, we employed the arithmetic mean of pre- and post-levels of urea and creatinine, as well as urea/creatinine clearance in urine. To properly quantify RKF, blood concentrations of one of the medium molecular weight proteins, such as β2M, cystatin C, and βTP, were not measured. Nonetheless, the current study's strength is in evaluating the relationship between the observed RKF and FAS score and its association with other laboratory data in this particular patient population. Additionally, we made an effort to use the same blood flow rate, dialysate flow rate, and dialysis period in both groups to arrange the dialysis treatment parameters as similarly as feasible.

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Conflicts of interest: Nil.

Ethical consideration

After describing the study's goal, procedure, and advantages to the patients, they provided informed written permission. The work was authorised by the Ain Shams University Faculty of Medicine's Research Ethics Committee (number: FMASU M S 642/2022 ON 27/9/2022).

References

[1] T. Li, C.S. Wilcox & M.S. Lipkowitz. (2019). Rationale and Strategies for Preserving Residual Kidney Function in Dialysis Patients. American Journal of Nephrology. 50(6):411-421. doi: 10.1159/000503805.

[2] C.A. White, S. Ghazan-Shahi & M. A. Adams. (2014). B-Trace protein: a marker of GFR and other biological pathways. American Journal of Nephrology. 65(1):131-46. doi: 10.1053/j.ajkd.2014.06.038.

[3] M. Bossola & L. Tazza. (2016). Postdialysis Fatigue: A Frequent and Debilitating Symptom. Semin Dial. 29(3):222-7. doi: 10.1111/sdi.12468.

[4] M. Bossola, S.S. Hedayati & A.D.H. Brys ADH. (2023). Fatigue in Patients Receiving Maintenance Hemodialysis: A Review. American Journal of Kidney Diseases. 82(4):464-480. doi: 10.1053/j.ajkd.2023.02.008.

[5] J. de Vries, H. Michielsen & V. Heck. (2004). Measuring fatigue in sarcoidosis: The Fatigue Assessment Scale (FAS). British Journal of Health Psychology. 9, 279-291.

[6] S. Debnath, R. Rueda, S. Bansal. (2021). Fatigue characteristics on dialysis and non-dialysis days in patients with chronic kidney failure on maintenance hemodialysis. BMC Nephrology. 22(1):112. doi: 10.1186/s12882-021-02314-0.

[7] J. Lee, Y.C. Kim & S. Kwon S. (2020). Impact of health-related quality of life on survival after dialysis initiation: a prospective cohort study in Korea. Kidney Research and Clinical Practice. 39(4):426-440. doi: 10.23876/j.krcp.20.065.

[8] Dr. Meraj & M. Sabiullah. (2019). Study of serum leptin levels in patients with chronic kidney disease. International Journal of Advanced Biochemistry Research. 3(1):21-26. DOI: 10.33545/26174693.2019.v3.i1a.28.

[9] S. Zyga, V. Alikari & A. Sachlas. (2015). Assessment of Fatigue in End Stage Renal Disease Patients Undergoing Hemodialysis: Prevalence and Associated Factors. Med Archives. 69(6):376-80. doi: 10.5455/medarh.2015.69.376-380.

[10] S. Suparti, S. Sodikin & E. Endiyono. (2020). The Relationship Between Dialysis Adequacy and Fatigue In Patients On Maintenance Hemodialysis. Jurnal Keperawatan Padjadjaran. 8(1), 1–8.

[11] Y. Obi, E. Streja & C.M. Rhee. (2016). Incremental Hemodialysis, Residual Kidney Function, and Mortality Risk in Incident Dialysis Patients: A Cohort Study. American Journal of Kidney Diseases. 68(2):256-265. doi: 10.1053/j.ajkd.2016.01.008.

[12] A. Elgendy, A.I. Abdelsalam & M. Mansour . (2022). Can residual kidney function affect quality of life and cognitive function in hemodialysis patients? BMC Nephrology. 23(1):263. doi: 10.1186/s12882-022-02892-7.

[13] J. Kong M. Davies & P. Mount. (2018). The importance of residual kidney function in haemodialysis patients. Nephrology. 23(12):1073-1080. doi: 10.1111/nep.13427.

[14] P. de-Sequera, E. Corchete & L. Bohorquez. (2017). Residual Renal Function in Hemodialysis and Inflammation. Therapeutic Apheresis and Dialysis. 21(6):592-598. doi: 10.1111/1744-9987.12576.

[15] E. Vilar, D. Wellsted & S.M. Chandna. (2009). Residual renal function improves outcome in incremental haemodialysis despite reduced dialysis dose. Nephrology Dialysis Transplantation. 24(8):2502-10. doi: 10.1093/ndt/gfp071.

[16] J.H. Kong, M.R. Davies & P.F. Mount. (2021). Relationship between residual kidney function and symptom burden in haemodialysis patients. Internal Medicine Journal. 51(1):52-61. doi: 10.1111/imj.14775.

[17] M. Bossola , E. Di-Stasio & M. Antocicco. (2012). Qualities of fatigue in patients on chronic hemodialysis. Hemodialysis International. 17(1):32-40. doi: 10.1111/j.1542-4758.2012.00713.x.

[18] S. Arhamawati, S. Saryono & S. Awaluddin. (2019). Correlation between the levels of urea serum, creatinine, and haemoglobin with fatigue in patient with chronic kidney disease at Haemodialisa Unit, dr. R. Goeteng Taroenadibrata General Hospital Purbalingga. Journal of Bionursing.1(1),34–46. https://doi.org/10.20884/1.bion.2019.1.1.8.