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The relationship between the adequacy of hemodialysis and laboratory parameters

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Original Article

Abstract

BACKGROUND: The present study was conducted in order to evaluate the factors affecting the adequacy of dialysis and determine the relationship of dialysis adequacy with laboratory parameters.

METHODS: This descriptive study was performed on 60 hemodialysis patients of Razi Medical Center of Qaemshahr, Iran, with the history of more than 3 months of dialysis. The participants were selected using census method. Data collection was conducted through a researcher-made questionnaire. Blood samples were collected to evaluate laboratory parameters. The adequacy of dialysis was calculated through the Kt/V parameter. The obtained data were analyzed using descriptive statistical tests.

RESULTS: According to the Kt/V criteria, the mean dialysis adequacy index was 1.6 ± 0.22 and 41.7% of the patients had the optimum dialysis adequacy (Kt/V of greater than 1.2), and 43.3% of patients had a dialysis adequacy which was close to the desirable level. There was a significant reverse relationship between dialysis adequacy and alkaline phosphatase (ALP), blood sugar, and body mass index (BMI). Nevertheless, there was no significant relationship between dialysis adequacy and parathyroid hormone (PTH), cholesterol, triglycerides, alanine aminotransferase (ALT), aspartate aminotransferase (AST), calcium, phosphorus, and the number of dialysis sessions per week, duration of each dialysis session, and the history of dialysis (P > 0.050).

CONCLUSION: In order to increase the adequacy of dialysis, the blood sugar level of patients should be controlled and patients should be advised to modify their weight using a suitable diet.

KEYWORDS: Dialysis, Hemodialysis, Enzymes

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Introduction

Hemodialysis is the most commonly utilized treatment in individuals with end-stage renal disease (ESRD).[1]

Inadequacy of hemodialysis is one of the chief causes of morbidity and mortality in patients with ESRD. High Kt/V is one of the main objectives of hemodialysis and has a significant effect on the prognosis of patients undergoing dialysis; therefore, the factors affecting it must be carefully controlled and monitored.[2] According to reliable sources, Kt/V of less than 0.8 is considered as a sign of inadequacy.[3]

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Given the facilities and limitations of dialysis beds in the country, it is essential to maintain the sufficient adequacy of dialysis in patients by medical interventions.[4] Since more efficientdialysis will improve the patients' status and their life expectancy with fewer side effects, it is very important to identify the factors affecting the adequacy of dialysis and how to increase its efficiency.[5]

In the case of dysfunctional hemodialysis, the patient will require higher frequency or duration of hemodialysis, which not only has additional treatment costs for the healthcare system of the country, but also has the risk of transmission of fatal infectious agents, such as hepatitis B and C, and HIV and other blood-borne infections. These issues illustrate the need for performing more effective hemodialysis.[5,6]

Desirable dialysis can improve quality of life (QOL) and increase life expectancy of patients. In addition, blood urea nitrogen (BUN) and creatinine (Cr) are short-term predictors of patients' condition and cannot show the condition of chronic dialysis patients. Thus, the present study was conducted to determine the relationship between the adequacy of hemodialysis and laboratory parameters in patients undergoing hemodialysis at Razi Hospital of Qaemshahr City, Mazandaran Province, Iran.

Materials and Methods

The present cross-sectional study was performed on 60 patients undergoing hemodialysis at Razi Hospital of Qaemshahr City. Inclusion criteria were the history of dialysis of more than 3 months (steadily) in this medical center, having an arteriovenous fistula, efficient shunt, being fully conscious, mental health, and the lack of emergency hemodialysis. Cases of death, traveling, or unwillingness to participate in the study were excluded. The research population included 74 patients on hemodialysis permanently in this center, of which 60 cases remained after the implementation of the exclusion criteria. The samples were selected through census and based on moral considerations. A researcher-made checklist was used to collect data on age, sex, height, dry weight, blood pressure, onset of dialysis, hemodialysis duration, number of dialysis per week, duration of dialysis each session, the period between 2 dialysis sessions, weight, Cr and BUN before and after the first session of dialysis, pre-dialysis weight before the second session, hemoglobin (Hb), hematocrit (Ht), blood type, filter type, type of dialyzer, and history of kidney transplant. The validity of the checklist was determined using content validity; this means that it was given to a number of experts in this field and their final opinions were applied.

The demographic and clinical data were obtained through interviews and observations. The blood pressure, height, and weight of patients (in a hospital gown and no shoes) were measured before dialysis. Blood samples were collected and sent to the laboratory before the first dialysis session, to measure BUN, Cr, Hb, Ht, sodium, potassium, parathyroid hormone (PTH), blood glucose, alkaline phosphatase (ALP), cholesterol, triglycerides, alanine aminotransferase (ALT), and aspartate aminotransferase (AST) and determine blood disorders. It should be mentioned that for sample preparation before dialysis, after the dialysis needles attached, blood samples were obtained from the arterial line, and it was attempted to carefully maintain heparin or normal saline in the arterial line before sampling. Evaluation of the characteristics of the dialysis machine during the dialysis performed observationally. At the end of dialysis, to avoid re-circulation of blood samples, 2 cc of blood clots was obtained using low flow speed method to evaluate BUN after dialysis. Thus, 2 minutes before sampling, the machine was set on 50 ml/minute, and after 30 seconds, samples were taken. Samples were collected from the arterial line (Seth) (above the dialyzer), since the

differences between arterial-venous urea concentration is low at the time. Blood samples were sent to the laboratory, and after receiving the test results, urea fraction ratio formula was used to calculate the reduction of blood urea, and logarithmic Daugirdas 2 formula was used to evaluate the adequacy of dialysis. After the dialysis, patient's weight and blood pressure were controlled.

It is noteworthy that blood samples for testing BUN, Cr, Hb, and Ht were immediately sent to the laboratory only in the morning shift and were measured by one of the employees of the laboratory. Blood tests were performed using an autoanalyzer (Elitekits, France) at Razi Hospital.

The collected data were analyzed using descriptive (mean and standard deviation) and inferential statistics (correlation and chi-square), with confidence level of 0.95 and test power of 0.80 in SPSS software (version 16, SPSS Inc., Chicago, IL, USA). The Kt/V level was calculated based on the logarithmic Daugirdas 2 formula:

$$Kt/V = IN (R-0.008t) + (4-3/5R) + UF/W$$

In which IN is the negative natural logarithm, R is BUN after dialysis divided by BUN before dialysis, T is time of dialysis in hours, UF is weight loss in kilograms during dialysis, and W is weight in kilograms after dialysis. In addition, urea reduction ratio (URR) is obtained through the following equation.

$$URR = 100 \times 1 - (\text{pre-dialysis urea}/\text{post-dialysis urea}).$$

Results

In this study, 60 patients were eligible to participate, of which 31 were women and 29 men. Their age range was 21 to 91 years with a mean age of 59.5 ± 16.5 years. Moreover, 58.3, 47.4, 29.8, 74.6, and 35.3 percent were, respectively, illiterate, housekeepers, self-employed, married, and residents of urban areas and 46.7% had blood type O+. In addition, 96.7% of the subjects had a history of kidney transplant, 3.8% had a history of smoking, 80% of patients had dialysis for 4 hours in each session, and 76.7% of subjects had dialysis 3 times a week. Filter type in 30% and 25% of cases was R60 and PS10, respectively (Table 1).

The mean onset of dialysis was 10.3 ± 7.5 months. The mean dialysis adequacy index based on the Kt/V criteria was 1.6 ± 0.2. The results showed that according to the Kt/V criteria, 42.4% of the patients had the optimum dialysis adequacy; this means that Kt/V of greater than 1.2% and 44.1% were close to the desirable level.

The mean Kt/V in female patients was 1.8 ± 0.3 and in men 1.5 ± 0.2; according to independent t-test, this difference was statistically significant ($P < 0.001$).

Based on Pearson's correlation coefficient, there was no statistically significant relationship between the number of dialysis sessions per week, history of dialysis, and dialysis duration in each session and Kt/v ($P > 0.050$). According to independent t-test, there was no statistically significant relationship between age and Kt/v ($P > 0.050$).

Among the subjects, 57.6% had normal body mass index (BMI), 30.5% were overweight, and 10.2% had BMI of less than normal.

The mean and SD of BMI among the subjects was 23.1 ± 3.7 kg/m^2 and it was in the range of 17.7-34.9. Based on Pearson's correlation coefficient, there was a statistically significant inverse relationship between BMI and adequacy of dialysis session ($P < 0.001$ and $r = -0.466$). In people who had a BMI of higher than normal, the dialysis adequacy was lower.

Mean and SD of PTH was 209.7 ± 246.1 pg/ml and it ranged between 0.1373 and 4. Based on Pearson's correlation coefficient, a significant relationship was observed between dialysis adequacy and PTH ($P > 0.050$).

The mean and SD of AST was 18.7 ± 6.9 IU/l and it ranged between 8 and 38. The mean and SD of ALT was 16.7 ± 8.1 IU/l and it ranged between 6 and 45.

Table 1. Frequency distribution of demographic and clinical information of patients

Variables		Frequency (%)
Gender	Female	31 (51.7)
	Male	29 (48.3)
Marital status	Single	6 (10.2)
	Married	44 (74.6)
	Divorced	8 (13.6)
	Widowed	1 (1.7)
Education level	Illiterate	35 (58.7)
	Secondary school	10 (16.7)
	Diploma	9 (15.0)
	University	6 (10.0)
Occupation	Housekeeper	27 (47.4)
	Employee	3 (5.3)
	Retired	8 (14.0)
	Unemployed	1 (1.8)
	Self-employed	17 (29.8)
	Student	1 (1.8)
Area of residence	Urban	32 (53.3)
	Rural	28 (46.7)
History of kidney transplant	Yes	1 (1.7)
	No	58 (98.3)
Type of dialysis filter	ps10	15 (25.0)
	R70	8 (13.3)
	PS13	17 (28.3)
	R60	18 (30.0)
	R80	2 (3.3)
Diet	Uremic	41 (68.3)
	Diabetic-uremic	14 (23.7)
	Diabetic-uremic-salting	2 (3.4)
	Uremic-salting	2 (3.4)
Number of dialysis sessions in a week	2	9 (15.0)
	3	46 (76.7)
	4	5 (8.3)
Duration of dialysis each session (hour)	3	1 (1.7)
	3.4	3 (5.0)
	3.5	8 (13.3)
	4	48 (80.0)
Blood type	A+	15 (25.0)
	O+	28 (46.7)
	AB+	3 (5.0)
	B+	8 (13.3)
	A-	3 (5.0)
	O-	2 (3.3)
	AB-	1 (1.7)
History of smoking	Yes	2 (3.8)
	No	51 (96.2)
Adequacy of dialysis	Favorable (greater than 1.2)	25 (42.4)
	Relatively favorable (1.2 to 0.8)	26 (44.1)
	Unfavorable (less than 0.8)	8 (13.6)

In addition, the mean and SD of ALP was 375.6 ± 233.6 IU/l and it ranged between 118 and 1490. Based on Pearson's correlation coefficient, dialysis adequacy had a significant negative correlation with ALP enzymes (P = 0.023, r = -. 296); those who had lower ALP, had a better dialysis adequacy.

Based on Pearson's correlation coefficient, there was no statistically significant relationship between dialysis adequacy and AST and ALT enzymes (P > 0.050). Furthermore, 60% of participants had fetal bovine serum (FBS) of higher than normal.

Mean and SD of FBS was 133.4 ± 54.8 mg/dl and it ranged between 50 and 319. Based on Pearson's correlation coefficient, there was a significant negative correlation between FBS and dialysis adequacy (P = 0.005, r = -0.357).

Mean and SD of cholesterol was 144.2 ± 38.4 mg/dl and it ranged between 50 and 245. The mean and SD of triglyceride was 170.6 ± 110.8 mg/dl. Based on Pearson's correlation coefficient, cholesterol and triglycerides had a significant relationship with dialysis adequacy (P > 0.050).

Mean and SD of calcium was 61.8 ± 48.1 mg/dl and it ranged between 1.90 and 11.50. The mean and SD of phosphorus was 6.5 ± 6.0 mg/dl and it ranged between of 2 and 54. Besides, the mean and SD of sodium was 139.1 ± 3.7 mg/dl and it ranged between 130 and 148. Moreover, the mean and SD of potassium was 4.5 ± 0.8 mg/dl and it ranged between 3 and 7.40 (Table 2).

Based on Pearson's correlation coefficient, there was no statistically significant relationship between the amount of calcium, phosphorus, sodium, and potassium and dialysis adequacy (P > 0.050).

The average Hb and Ht, ferritin, total iron-binding capacity (TIBC), and serum iron in patients were 10.97 g/dl, 34.61%, 272.6 ng/ml, 460.6 ng/ml, and 102.03 mg/dl, respectively. Based on Pearson's correlation coefficient, the adequacy of dialysis did not have a significant relationship with Hb, Ht, ferritin, serum iron, and TIBC (P > 0.050).

HIV Ab and HBsAg in all samples were negative. However, hepatitis C virus (HCV) Ab was negative in 96.7% and positive in 3.3% of subjects.

Table 2: laboratory findings and their relationship with dialysis adequacy

Laboratory criteria	Mean ± SD	Minimum	Maximum	P
FBS (mg/dl)	54.78 ± 133.41	50.0	319.0	0.005
TIBC (ng/ml)	272.56 ± 58.51	35.0	408.0	0.650
Ferritin (ng/ml)	460.57 ± 313.36	25.0	1000.0	0.600
Serum Iron (mg/dl)	102.03 ± 68.78	37.0	450.0	0.330
Hb (g/dl)	10.97 ± 2.31	6.0	18.2	0.310
Ht (%)	34.61 ± 6.50	20.4	54.3	0.140
TG (mg/ml)	170.57 ± 110.78	30.3	600.0	0.450
Cholesterol (mg/dl)	144.18 ± 38.38	50.0	245.0	0.290
PTH (pg/dl)	209.76 ± 246.10	4.0	1373.0	0.660
AST (IU/l)	18.70 ± 6.89	8.0	38.0	0.240
ALT (IU/l)	16.73 ± 8.12	6.0	45.0	0.730
ALP (IU/l)	375.61 ± 233.57	118.0	1490.0	0.023
Ca (mg/dl)	8.61 ± 1.48	1.9	11.5	0.370
P (mg/dl)	6.00 ± 6.53	2.0	54.0	0.310
Na (mg/dl)	139.10 ± 3.75	130.0	148.0	0.840
K (mg/dl)	4.49 ± 0.81	3.0	7.4	0.700
Albumin (g/dl)	4.21 ± 0.81	2.1	6.0	0.620

FBS: Fetal bovine serum; TIBC: total iron-binding capacity; Hb: Hemoglobin; Ht: Hematocrit; TG: Thyroglobulin; PTH: Parathyroid hormone; AST: Aspartate aminotransferase; ALT: Alanine aminotransferase; ALP: Alkaline phosphatase; Ca: Calcium; P: Phosphorus; Na: Sodium; K: Potassium

Discussion

In this study, the mean dialysis adequacy index based on the Kt/V criteria was 1.6 ± 0.22, and URR was 60.81 ± 10.73. Furthermore, 41.7% of patients had the optimum dialysis adequacy (Kt/V of greater than 1.2) and 20% had URR of greater than 65%.

The results of the study by Tayyebi et al. on the adequacy of dialysis showed that half of the patients (50.5%) had desirable dialysis adequacy (Kt/V of greater than 1.2) and only 46% had a URR of 65% (6) that is in agreement with the results of the current study.[7]

In the study of Mogharab et al. on hemodialysis patients at the Educational Hospital of Birjand, Iran, the average Kt/V was 1.17, and in 70% of the patients, Kt/V was between 0.9 and 1.3.[4] Moreover, the average URR was 62.8, and in 66% of patients, it ranged between 61% and 70%, and the adequacy of dialysis was relatively desirable.[4]

In the study of Hojjat on the adequacy of dialysis, the mean Kt/V was 0.93, which is a sign of low adequacy of dialysis.[3]

In this study, 46.7%, 25%, and 13.3% of the participants were O+ ,A+, B+ blood type, respectively. In the study of Tayyebi et al., the majority of patients (43%) were A+ and the least number were AB^+ (5%).[7]

In the present study, 2 patients had positive anti-HCV and its prevalence was 3.3%, and HIV Ab and HBsAg were negative in all samples.

Joukar et al. conducted a study on the genotype of hepatitis C virus in hemodialysis patients with hepatitis C in Gilan Province, Iran.[8] The results showed that from among 514 patients undergoing hemodialysis in the whole province, 61 patients had positive anti-HCV and its prevalence was reported as 11.9%.[8]

Khoushbaten et al. conducted a study on the prevalence of antibodies against hepatitis E in patients undergoing hemodialysis in Tabriz, Iran. They found that the average duration of hemodialysis was 37.7 months and total seroprevalence of hepatitis E was 7.4%. They also found that 4.6% of patients were HBsAg positive and 20.4% were HCV Ab positive. Moreover, they found that demographic variables did not have a significant relationship with blood-borne viral infections among patients with hepatitis E.[9]

In this study, there was no statistically significant relationship between the adequacy of dialysis and PTH, calcium, phosphorus, sodium, and potassium.

Mousavi Movahed et al. conducted a study on the amount of calcium, phosphorus, and PTH and their relationship with calcification of heart valves in patients undergoing hemodialysis.[10] The results showed that the amount of PTH had a significant relationship with calcification of heart valves. Nevertheless, the amount of calcium and phosphorus, diabetes, hypertension, hyperlipidemia, the product of calcium-phosphorus, and duration of dialysis showed no significant association with calcification of heart valves.[10]

In the present study, adequacy of dialysis was found to have a statistically significant reverse relationship with ALP enzymes; those who had lower ALP also had better dialysis adequacy. However, no statistically significant relationship was observed between the adequacy of dialysis and AST and ALT enzymes.

In this study, the amount of cholesterol and triglycerides did not have a significant relationship with the adequacy of dialysis. Moreover, the amount of Cr and BUN was significantly reduced after dialysis compared to their pre-dialysis amount and showed a statistically significant difference.

In this study, of the 60 patients eligible for the research, 31 were women and 29 men. The mean Kt/V of women was higher than men, and there was a statistically significant relationship between sex and Kt/V. This is likely due to the similar dialysis filter in both sexes, which resulted in a better dialysis for women due to the smaller size, less weight, and distribution of urea.

In the study of Mogharab et al., 68% of patients were men, and a statistically significant difference was observed between men and women in terms of Kt/V and dialysis adequacy.[4] In the study of Hojjat, 64.7% of patients were men, and dialysis quality had a significant relationship with gender.[3] These results are consistent with that of the present study. However, in the study of Raeisifar et al. on 45 patients, 25 were women, and there was no statistically significant relationship between gender and dialysis adequacy.[11] In the studies of Monfared et al.[12] and Tayyebi et al.,[7] the adequacy of dialysis had no statistically significant relationship with gender.

In this study, the mean age of patients was 59.55 ± 16.47 years and there was no statistically significant relationship between age and Kt/V ($P > 0.050$). In the study of Raeisifar et al., the mean age of the participants was 53.5, and there was no statistically significant relationship between age and dialysis adequacy.[11] In the study of Mogharab et al., the mean age of patients was 47.70 ± 16.72 years, and there was no statistically significant relationship between age and Kt/V.[4] Furthermore, in the study of Monfared et al., no statistically significant relationship was found between age and dialysis adequacy.[12] These results were consistent with that of the present study. Nevertheless, the overall mean age of patients in this study was higher.

In the present study, the association between BMI of patients and Kt/V was statistically significant. The mean BMI of the subjects was 23.10 ± 3.74 kg/m^2, which is in the normal range (20-25). This can be effective on improving dialysis adequacy, because a BMI of less than 20 indicates malnutrition, blood urea reduction due to reduced protein intake, and decreased metabolism.

In this study, 61.7% of patients had Hb of less than 11 g/dl and the mean Hb, Ht, ferritin, and TIBC in patients were 10.97 g/dl, 34.61%, 460.57 ng/ml, and 272.56 ng/ml, respectively. However, dialysis adequacy did not have a statistically significant relationship with Hb, Ht, ferritin, and TIBC ($P > 0.050$)

Considering the high prevalence of anemia in patients undergoing hemodialysis, blood loss should be prevented during dialysis procedures and nutrition advice should be provided by an expert.

In this study, there was no statistically significant relationship between serum albumin and dialysis adequacy. However, in the study of Monfared et al.,[12] serum albumin levels were significantly related to the adequacy of hemodialysis; those who had undesirable dialysis adequacy were adversely affected by hypoalbuminemia.[4] The difference with this study can be due to almost normal serum albumin levels in all units of the study.

Mean and SD of PTH was 209.76 ± 246.10 pg/dl. No significant relationship was observed between dialysis adequacy and PTH. In addition, there was no statistically significant relationship between PTH, alkaline phosphatase, Hb, and Ht. The results of the study by Baradaran et al. on the role of secondary hyperparathyroidism on anemia of patients with ESRD undergoing hemodialysis showed that PTH and alkaline phosphatase levels had an inverse correlation with Hb and Ht.[13]

The average fasting blood sugar in the participants of this study was 133.41 mg/dl. A significant inverse relationship was observed between dialysis adequacy and fasting blood sugar; those who had high blood sugar experienced lower dialysis adequacy.

In the present study, 80% of patients experienced 4 hours of dialysis each session and 76.7% of subjects underwent dialysis 3 times a week. In the study of Mogharab et al., 88% of subjects experienced 4 hours of dialysis each session and 62% underwent dialysis 3 times a week.[4]

In this study, the mean Kt/V of patients who underwent dialysis 3 times per week was higher than those who underwent dialysis

twice a week. This finding is in agreement with that of Mogharab et al.[4] It seems that through revising the strategy intended for patients on dialysis and changing their plans from 2 times to 3 times a week their dialysis adequacy can be increased.

In the present study, the majority of subjects were illiterates (58.3%), and this should be considered by health personnel in providing the required training for patients.

Mogharab et al. found that dialysis adequacy had a significant relationship with the number of dialysis sessions per week, BMI, and average blood pump.[4] Nevertheless, the relationship of age and duration of dialysis sessions with dialysis adequacy during dialysis sessions was not significant.[8] Zerati et al. conducted a study on the factors affecting dialysis adequacy in patients undergoing hemodialysis. The results showed that the most important factor in dialysis adequacy was the insufficient dose of dialysis.[14]

The results of the study by Tayyebi et al. on the relationship between blood pressure and dialysis adequacy in patients undergoing hemodialysis showed a significant association between blood pressure and the dialysis adequacy indices of URR and Kt/V.[7] The results of the study by Roozitalab et al. on the adequacy of dialysis in patients undergoing hemodialysis showed a statistically significant difference in BUN before and after dialysis.[15] In the study of Hojjat, there was a statistically significant difference in blood pressure, weight, BUN, and Cr before and after the dialysis session.[3]

Conclusion

Based on the above mentioned issues, the overall results of Kt/V and URR showed the favorable and acceptable quantity and quality of dialysis. According to studies carried out in Iran in the field of dialysis adequacy, there are different levels of inadequate dialysis in each center.

Therefore, it is necessary to determine the cause of this inadequacy in all patients, and then, take the necessary steps to improve dialysis adequacy, and in turn, increase the QOL of dialysis patients. It is also necessary to calculate dialysis dose specifically for each individual, and dialysis time should be prescribed based on patients' needs. Moreover, filters compatible with the patient's body must be used. In addition, since the lack of cooperation in patients is the leading cause of shorter time of dialysis or its cancellation, the necessary trainings should be provided regarding the prescribed time for dialysis, timely visits, and appropriate diet.

Conflict of Interests

Authors have no conflict of interests.

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