www.nephropathol.com DOI: 10.34172/jnp.2022.17322 J Nephropathol. 2022;11(4):e17322

Journal of Nephropathology

Evaluation of dialysis adequacy based on Kt/V and its related factors among patients undergoing hemodialysis in Guilan dialysis centers

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ARTICLE INFO

Article type:
Original Article

Article history:
Received: 30 November 2021
Accepted: 11 February 2022
Published online: 20 February 2022

Keywords:
Dialysis adequacy
Chronic kidney failure
End-stage renal failure

ABSTRACT

Introduction: Adequate and effective dialysis can improve patients' quality of life and reduce kidney failure complications and mortality in end-stage renal disease on hemodialysis.

Objectives: This study aimed to evaluate dialysis adequacy based on Kt/V and its related factors among patients undergoing hemodialysis.

Patients and Methods: This cross-sectional, multi-center study was conducted during six months on hemodialysis patients referred to dialysis centers of the Guilan province in the north of Iran. Dialysis adequacy was evaluated using Kt/V (>1.2) criteria.

Results: The mean Kt/V was 1.24±0.36 with a median of 1.2. Adequacy of dialysis was desirable in 51.2% of the patients. There was a significant and inverse relationship between body mass index (BMI) and Kt/V (r=-0.139, $P=0.013$). The relationship between Kt/V criterion and pre-dialysis weight (r=-0.310, $P=0.00$) and post-dialysis weight (r=-0.314, $P=0.00$) were inverse. The Kt/V criterion was significantly associated with calcium (Ca) level and the patients with normal Ca level had a higher adequacy than those in the other levels of Ca [normal versus low level, mean difference (MD): 0.19±0.06; normal versus high level, MD: 0.07±0.04, $P<0.001$). The Kt/V criterion was inversely related to blood pressure and temperature before and after dialysis ($P<0.05$).

Conclusion: The present study showed a close correlation between blood pressure, Ca level and BMI with dialysis adequacy based on Kt/V criteria. The findings obtained here suggested treatment strategies based on correction of Ca levels, BMI and blood pressure prior to dialysis to increase the adequacy of dialysis.

Implication for health policy/practice/research/medical education:
In a cross-sectional, multi-center study on hemodialysis patients in the north of Iran, we found a significant positive relationship between the years of dialysis and Kt/V dialysis adequacy (r=0.131).

Please cite this paper as: Mortazavi Khatibani SS, Yaseri M, Fayazi HS, Ramzanzadeh ER, Hajipoor A. Evaluation of dialysis adequacy based on Kt/V and its related factors among patients undergoing hemodialysis in Guilan dialysis centers. J Nephropathol. 2022;11(4):e17322. DOI: 10.34172/jnp.2022.17322.

Original Article

Introduction

Chronic renal failure is known as one of the chronic and life-threatening diseases that leads to irreversible reduction of kidney function. End-stage renal disease (ESRD) is the final stage of chronic kidney disease (CKD). The prevalence of all the stages of CKD, including ESRD, is increasing, with an estimated 500 million people worldwide (1). To prevent uremia and its complications, patients need kidney replacement therapy, such as hemodialysis and peritoneal dialysis for the rest of life (2). Hemodialysis is one of the most important therapies for patients with acute renal failure, through which waste products, such as urea and toxins, are exerted. Inadequate dialysis can lead to increase in morbidity and mortality rates among chronic patients. In addition, in case of inefficient dialysis, the patient needs further dialysis sessions, which imposes additional costs and affects their quality of life. Therefore, the adequacy of dialysis is one of the important issues (3). Although dialysis preserves patients' life and prolongs it, it cannot fully perform kidney functions (4). Hemodialysis patients

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experience several issues due to the specific physical and mental conditions of their disease. Thus, the quality of dialysis is an important factor and effective in reducing these problems (5). The problems such as depression, anxiety, stress and suicide in these patients indicate their need to support; therefore, they could adapt to the disease (6). Numerous parameters, such as fluid and electrolyte balance control, are conducted clinically to evaluate the dialysis adequacy (7). Clinical studies have identified the key indicator of dialysis adequacy as Kt/V, where K is the dialysis clearance for blood urea, T is the duration of dialysis per hour and V is the volume of urea distribution in the body (8). According to previous research, Kt/V index is associated with several factors, such as duration of hemodialysis and blood flow rate (9,10), increased albumin level (11), urea level before and after dialysis (12) and type of filtration (13). Even though the current hemodialysis methods are effective, inadequate dialysis is one of the important factors increasing mortality in these patients, which can cause disability and increased hospitalization.

Objectives

On account of the importance of the subject of this study, we aimed to evaluate the adequacy of dialysis based on Kt/V and associated factors among the patients undergoing hemodialysis in Guilan dialysis centers, north of Iran.

Patients and Methods

Study design and population

In this cross-sectional descriptive-analytical study, all the patients undergoing hemodialysis in dialysis centers in Guilan province, including Caspian, Razi, Aria, Golsar, Pars, Kianmehr and Anzali dialysis centers, were included in the study population. The sampling method was census of all the dialysis patients in the seven dialysis centers for a period of six months. The subjects over the age of 18 who had spent more than three months on dialysis in these centers were included in the study. Those with intolerance to dialysis due to certain problems, like sepsis, acute febrile illness, muscle cramps, respiratory distress, decreased level of consciousness, seizures and acute coronary syndrome and patients with incomplete information were excluded from the study. Prior to starting the process of the study, the patients from whom blood samples were obtained filled out informed consent form. Demographic information (age, gender and age of onset for dialysis), body mass index (BMI) and laboratory tests, including serum creatinine (Cr), calcium (Ca), phosphorous (Ph), albumin (Alb), uric acid, 25-hydroxy vitamin D, sodium (Na), potassium (K) and intact parathyroid hormone (iPTH) and also plasma hemoglobin (Hb), were recorded in order to evaluate the adequacy criteria of dialysis. Serum blood urea nitrogen (BUN) was primarily measured after dialysis by slow blood flow in order to prevent the effect of recirculation. Initially, the blood flaw rate was reduced to 50 cc/min and after 3 minutes, the sampling was performed. The BUN tests were calculated using Mann kit and value of (Kt/V>1.2) was considered as the optimal dialysis adequacy.

Statistical methods

Normality distribution of the data was assessed by Kolmogorov-Smirnov test. Descriptive results were reported as median/mean (SD) for quantitative variables and n (%) for qualitative variables. Mann-Whitney U test and Kroskal-Wallis test were conducted to determine the relation between Kt/V and the studied variables. The level of significance was considered to be less than 0.05. Analysis was conducted with SPSS software version 22.

Results

Data of 344 patients under hemodialysis were analyzed. The majority of the study population consisted of male patients (55.4%). The dialysis was mostly conducted in the morning (44.8%). The majority of dialysis patients had normal BMI and 14.3% were obese. Most of the patients lived in the city and finished high school (34%). Evaluating urinary status, the majority (88.8%) of the patients were oliguric and only 11.1% were anuric. The mean Kt/V was 1.24 ± 0.36 with a median of 1.2. Adequacy of dialysis was desirable at 51.2% of the patients. Most of the patients had blood types of O+ (36.4%), A+ (27.8%), and B+ (18.9%). Moreover, the most common cause of end-stage renal disease was related to hypertension (49.8%) and diabetes mellitus (DM) (27.4%). The patients' characteristics are reported in Table 1. There was a significant and inverse relationship between BMI and Kt/V (correlation=-0.139, $P=0.013$). Dialysis adequacy was not significant regarding BMI ($P=0.073$); however, in thin patients, the mean index was high (Figure 1). According to Spearman's correlation results, the relationship among Kt/V criterion, pre-dialysis weight (correlation=-0.310, $P=0.00$), and post-dialysis weight (correlation=-0.314, $P=0.00$) was inverse and significant. Meanwhile, no relations were found between these factors and weight changes (correlation=0.104, $P=0.057$). There was a significant positive relationship between years of dialysis and Kt/V dialysis adequacy (Spearman's correlation=0.131, $P=0.017$). The Kt/V criterion was significantly associated with the Ca level; accordingly, the patients with normal Ca level had a higher adequacy than those with other levels of Ca [normal versus low level, mean difference (MD] of 0.19±0.06; normal versus high level, MD: 0.07±0.04, $P<0.001$; Table 2). According

Table 1. Patients' characteristics

Variable	Level	n	%
Gender	Female	147	44.55
	Male	183	55.45
BMI (kg/m²)	Thin	8	2.49
	Normal	189	58.88
	Over weight	78	24.30
	Fat	46	14.33
Educational level	Primary	58	29.44
	Under diploma	56	28.43
	Diploma	67	34.01
	Academic	16	8.1
Marital status	Single	13	6.70
	Married	175	90.21
	Other	6	3.1
Urinary condition	Oliduria	112	88.89
	Anuria	14	11.11
Diagnosis	Acute renal failure	2	0.68
	Chronic renal failure	290	99.32
Cause of ESRD	DM	88	27.41
	HTN	160	49.84
	GMN	11	3.43
	Unknown	33	10.28
	PKD	20	6.23
	Other	9	2.8
Blood type	O^+	119	36.39
	O^-	19	5.81
	A^+	91	27.83
	A^-	19	5.81
	B^+	62	18.96
	B^-	9	2.75
	AB^+	8	2.45
Dialysis adequacy (Kt/V)	No	168	48.84
	Yes	176	51.16

BMI; body mass index, ESRD; end-stage renal disease, HTN; hypertension, GMN; glomerulonephritis, PKD; polycystic kidney, DM; diabetes mellitus.

to the results of Table 3, Kt/V was inversely related to blood pressure and temperature before and after dialysis (P<0.05). As shown in Table 4, there were no significant relationships between dialysis adequacy and the type of vascular access.

Discussion

Hemodialysis is one of the most important treatments for patients with acute and chronic renal failure. Adequate and effective dialysis improves patients' quality of life and reduce kidney failure complications and mortality in ESRD. Diagnosis of dialysis adequacy is not easy. Several parameters, such as fluid and electrolyte balance control, are employed clinically; however, the most commonly used parameter is the Kt/V value. Performing adequate and effective dialysis is essential to improve patients' quality-of-life and decrease the complications of kidney failure (14,15). However, evidence regarding the effectiveness of dialysis among Iranian patients undergoing hemodialysis

Table 2. Mean dialysis adequacy in term of laboratory test

Parameter	Level	Mean	SD	Median	*P* value
Hemoglobin level	Low	1.25	0.37	1.21	0.503
	Normal	1.24	0.36	1.21	
	High	1.08	0.31	1.09	
Ca	Low	1.10	0.35	1.10	<0.001*
	Normal	1.29	0.37	1.24	
	High	1.22	0.26	1.17	
Phosphorus	Low	1.18	0.31	1.18	0.129
	Normal	1.26	0.35	1.23	
	High	1.19	0.39	1.14	
Albumin	Low	1.19	0.53	1.15	0.54
	Normal	1.21	0.35	1.17	
	High	-	-	-	
Acid uric	Low	1.31	-	1.31	0.143
	Normal	1.26	0.39	1.19	
	High	1.13	0.33	1.13	
Vitamin D	Lake	1.17	0.2	1.17	0.870
	Insufficient	1.15	0.26	1.11	
	Normal	1.19	0.33	1.12	
	High	1.01	0.27	1.01	
Na	Low	1.66	-	1.66	0.344
	Normal	1.24	0.36	1.20	
	High	1.38	0.49	1.38	
Potassium	Low	1.16	0.24	1.24	0.455
	Normal	1.25	0.36	1.22	
	High	1.20	0.42	1.14	
iPTH	Low	1.24	0.33	1.17	0.706
	Normal	1.27	0.5	1.19	
	High	1.17	0.31	1.19	

*Significant.

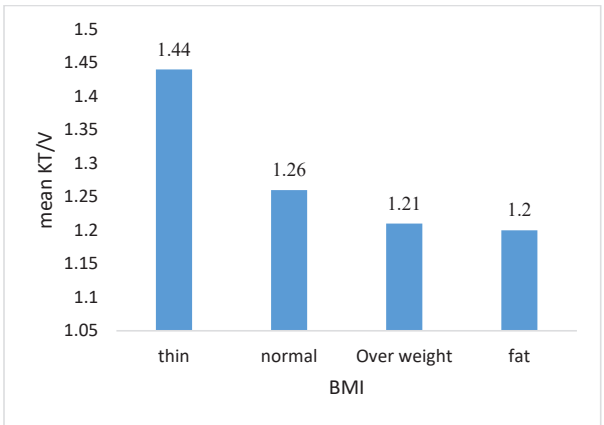

Figure 1. Comparison of dialysis adequacy KT/V in hemodialysis patients in terms of BMI level.

Table 3. Correlation of dialysis adequacy with vital signs

Parameter	Level	Correlation (r)	*P* value
Diastolic blood pressure	Before	-0.138	0.01*
	After	-0.184	0.001*
Systolic blood pressure	Before	-0.181	0.001*
	After	-0.221	0.000*
Blood temperature	Before	-0.132	0.015*
	After	-0.148	0.007*
Respiratory rate	Before	0.035	0.523
	After	0.063	0.255
Pulse rate	Before	0.019	0.727
	After	0.014	0.797

* Significant at level of 0.05.

Table 4. Mean of dialysis adequacy in term of the type of vascular accessess

Parameter	Type	Mean	SD	Median	P value
Vascular access	AVF	1.26	0.35	1.23	0.197
	CVC	1.23	0.38	1.19	
	Graft	1.19	0.37	1.16	

CVC, central venous catheter; AVF, arteriovenous fistula.

is inconclusive. This study aimed to evaluate dialysis adequacy based on Kt/V and its related factors amongst the patients undergoing hemodialysis in Guilan dialysis centers. The results of the present work revealed that the mean of Kt/V was 1.24 ±0.36 with a median of 1.2. Adequacy of dialysis was desirable in 51.2% of the patients and male patients were found to be at a higher risk. Similar results were reported in a recent study by Somji et al, on 143 patients undergoing hemodialysis in some dialysis centers in Tanzania, only 40.6% (based on Kt/V) of their patients received adequate hemodialysis and the mean Kt/V was 1.1, also, 65.7% of the study population were males (16). According to a systematic review and meta-analysis in 2018, the mean urea kinetic modelling (Kt/V) in Iranian patients undergoing hemodialysis was 1.11% (CI: 1.03-1.81) (17). These recent findings were in accordance with those obtained in our study. The results of other studies, which reported the average Kt/V index to be more than 1.2, were also in line with our outcomes herein (13,14). However, in another study, the mean Kt/V criteria was under the value of 1.2, which indicates inadequate dialysis (15). One of the reasons behind the difference in the results could be the appropriate dialysis conditions in the present study.

The strength of this study was its multicenter design. The result that makes our study superior over other works is that the Kt/V criterion was found to be significantly associated with Ca level; thus, the patients with normal Ca level had a higher adequacy than those with other levels of Ca. This relation was not touched on in any previous studies. Anemia could be an indicator for inflammation and malnutrition, that can influence Kt/V and was assessed based on hemoglobin level in this study. In a previous paper, patients with hemoglobin less than 10 g/dL had less adequate hemodialysis in comparison to those who had hemoglobin of 10 g/dL (17). According to some other studies, dialysis adequacy is related to serum albumin levels; therefore, with the increase in albumin levels, the Kt/V index increases (11,18). Furthermore, we found that the Kt/V criteria was inversely related to vital signs, such as blood pressure (systolic and diastolic) and temperature, before and after dialysis. One of the reasons for the difference between the results could be the fact that hypertension is highly prevalent in the northern Iranian population. There was a significant and inverse relationship between BMI and Kt/V (r=-0.139). The relationship among Kt/V criterion, pre-dialysis weight (r=-0.310), and post-dialysis weight (r=-0.314) was inverse. This finding suggested that the adequacy of dialysis cannot be measured solely on the basis of dialysis machines, but the biographical characteristics of the individual may affect it. The results of the present study implied a significant positive relationship between the years of dialysis and Kt/V dialysis adequacy (r=0.131). This finding was in line with the results reported in other studies (16). According to their paper, the longer the years of dialysis, the higher its quality.

Conclusion

The current study indicated a close correlation between blood pressure and Ca level and between higher BMI and dialysis adequacy based on Kt/V criteria. The findings herein suggested treatment strategies based on correction of Ca levels, losing weight in cases with high BMI and treatment of patients' blood pressure before dialysis in order to increase the effectiveness of dialysis adequacy. Thus, an effort to educate ESRD patients and staff involved in dialysis in order to raise their awareness, improve the dialysis adequacy, and reduce its complications seems to be of great necessity. To evaluate the long-term prognosis of patients, it could be recommended to determine whether higher Kt/V levels in ESRD patients are associated with a better prognosis in the future studies.

Limitations of the study

Limitations of our study were: limited study population and lack of follow-up of patients to determine the causes of poor quality dialysis.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contribution

Conceptualization: SSM, MY. Methodology: MY, HSF, ER, AH. Validation: HSF, SSM. Formal Analysis: SSM, MY. Investigation: ER, AH. Resources: SSM, MY. Data Curation: SSM, MY. Writing—Original Draft Preparation: ER, AH, MY. Writing—Review and Editing: SSM, HSF. Visualization: SSM, HSF. Supervision: SSM. Project Administration: SSM, HSF.

Conflicts of interest

The authors declare that they have no competing interests.

Ethical issues

This study was conducted in accordance with the tents of the Declaration of Helsinki and was approved by the ethical committee at the Guilan University of medical sciences [Ethical code #IR.GUMS.REC.1396.306]. Accordingly, written informed consent was taken from all participants before any intervention. This study was extracted from M.D., thesis of Azin Hajipoor at this university (Thesis #306). Besides, ethical issues (including plagiarism, data fabrication, double publication) have been completely observed by the authors.

Funding/Support

None.

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