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Evaluation of hemodialysis adequacy using urea reduction rate and related factors in Iranian patients' undergoing hemodialysis in Guilan, Iran

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ABSTRACT

Introduction: Dialysis quality is an important factor in reducing inability and mortality in chronic kidney failure patients and can enhance their life quality and social activity.
Objectives: The aim of this investigation was to examine the efficacy of dialysis based on urea reduction rate (URR) and the associated factors in hemodialysis patients due to the lack of clarity on the adequacy of dialysis.
Patients and Methods: This multicenter cross-sectional study was conducted on 344 hemodialysis patients over 18 years and referred to seven dialysis centers in Guilan, Iran. The adequacy of dialysis was obtained using URR (>65%) criteria.
Results: The mean URR of studied patients was 63 ± 10.4%. The desirable dialysis adequacy was reached in 45.9% of the patients. There was a significant negative association between URR and BMI (r= -0.155, $P = 0.005$). Patients who had normal calcium levels had significantly higher URR adequacy than patients with abnormal calcium levels ($P < 0.001$). The URR criterion was contrariwise associated to blood pressure before and after dialysis ($P < 0.05$). There was a significant association between the length of the time, patients underwent dialysis (in year) and URR (R=125, $P = 0.023$).
Conclusion: This study indicated that URR is a desirable criterion for dialysis adequacy, which was associated with blood pressure, serum calcium level and body mass index (BMI). These findings suggest providing treatment strategies based on these findings to enhance the effect of dialysis adequacy.

Implication for health policy/practice/research/medical education:
Several studies illustrated that a rate of urea reduction rate (URR) of more than 65% can be an effective indicator of improving dialysis patients' prognosis. The rising trend of chronic kidney disease and the absence of adequate dialysis are the main causes of death in patients with kidney complications. Our findings suggested providing treatment strategies to enhance the efficiency of dialysis adequacy.
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Introduction

Chronic kidney failure is a progressive disorder in which the ability of the body to maintain fluid, electrolyte balance, and metabolic waste excretion is lost, leading to uremia (1,2). End-stage renal disease (ESRD) is the final stage of chronic kidney disease and is defined as the stage that requires renal replacement therapy or hemodialysis (3). It is reported that over 70% of patients with ESRD are living in low-income countries (4). In Iran and many countries, the most common treatment method is hemodialysis. The purpose of dialysis is to remove the excess material and stabilize the body's internal environment as well as remove the toxins that cause permanent injury (5). Hemodialysis is one of the most common and alternative therapies for the kidney in cases with advanced chronic kidney disease. Evaluation of dialysis adequacy requires accuracy in measurement and increasing its quality is an important goal in dialysis programs (6).

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The better dialysis, the more life expectancy, and the fewer complications; therefore, identifying the effective factors in improving the quality of dialysis and how to increase its quality is important. The low adequacy of dialysis is one of the main causes of mortality in hemodialysis patients (7,8). Volume overload is common in patients receiving hemodialysis, leading to high blood pressure, functional and structural abnormalities of the heart and increased mortality (9). Approximately half of the patients did not have an optimal level of hemodialysis adequacy which needs to be reviewed and corrected. Patients with ESRD are incapable of living without dialysis support (10). The aim of hemodialysis is to remove and preserve toxins from the body, as its intracellular and extracellular composition in normal range as much as possible. Multiple individuals and personnel factors affect hemodialysis adequacy directly or conversely (11). The most common underlying causes of chronic kidney diseases are hypertension (HTN) and diabetes mellitus (DM). Dialysis adequacy is significantly associated with increased dialysis frequency, blood flow rate, vascular access, inter-dialytic weight gain, and dialysis time, in which the inadequacy of dialysis is one of the causes of inability in patients who undergo hemodialysis (12,13).

Hemodialysis adequacy refers to how well toxic products are removed from the patient's blood, which has a significant impact on patient's health. Dialysis delivery should be appropriate to improve the adequacy of life and to prolong survival. A wide range of methods has been used to evaluate the adequacy of dialysis. Of the three common methods (urea kinetic modeling, Kt/V, and urea reduction rate [URR]) that are considered proper for measuring the delivered dose of hemodialysis, the URR is the simplest to perform, which is the parameter most commonly used to express the dialysis dose and popularity of the URR (14,15). The URR is a statistically significant predictor of mortality for ESRD patients (16). Several studies have shown that a rate of URR of more than 65% can be an effective indicator of improving dialysis patients' prognosis. The rising trend of chronic kidney disease and absence of adequate dialysis are the main causes of death in patients with kidney complications (17).

Patients and Methods

Study design

The participants of this multicenter cross-sectional study, were hemodialysis patients with the age over 18 years that had spent over than three months on dialysis, in seven dialysis centers of Guilan, Iran. The sampling method was census on total number of 344 patients in seven dialysis centers during six months in 2017. Patients who were intolerant to dialysis due to some complications such as acute febrile illness, sepsis, respiratory distress and also patients with incomplete recorded data were excluded from the study.

All patients evaluated once in the second dialysis session per week. Information needed to evaluate the adequacy of dialysis was collected through the data collection form included: demographic information such as age, gender, age of onset for dialysis, body mass index (BMI), laboratory testes (parathyroid hormone, creatinine, hemoglobin, phosphorous, calcium, uric acid, albumin, 25 (OH) vitamin D, potassium, and sodium, and vital sign (blood pressure, respiratory rate, temperature, heart rate),vascular access (arteriovenous [AV] fistula, central venous catheter [CVC], graft), blood group type, ESRD cause, type of dialysis machines, number of dialysis sessions per week and duration of dialysis per session ,urinary status and blood flow rate. Dialysis adequacy was assessed using URR criteria. The URR> 65% were considered as optimal dialysis adequacy criteria. All recorded tests are related to the patient's last test, except for the serum blood urea nitrogen (BUN), which was measured first and immediately after the end of dialysis in the same session and by slow blood flow to avoid the recirculation effects, in this way the blood flow rate was reduced to 50 cc/min and after 2-3 minutes, sampling was conducted. URR is calculated as follows formula and can be assessed by measuring the BUN level before and after dialysis.

$$URR = \frac{(predialysis\ BUN - postdialysis\ BUN)}{(predialysis\ BUN) \times 100\%}$$

Statistical analysis

Data distribution was analyzed by the Kolmogorov-Smirnov test to evaluate normality. The results were illustrated as median/mean (±SD) and n (%) for quantitative and qualitative variables, respectively. The Mann-Whitney U and Kruskal-Wallis tests were conducted to the evaluate relation between URR and the variables. Analysis was performed by SPSS (version 22) with the P value less than 0.05.

Results

This study included a total of 344 patients with end stage renal disease who were on hemodialysis and they were evaluated for dialysis adequacy. Due to the patients' characteristics that were summarized in Table 1. In this study, 55.4% of patients were male, 44.6% were female, and 38.6% were overweight and obese. In the majority of patients, the blood type of O^+ was seen in 36.4%, type of A^+ in 27.8%, and type of B^+ in 18.9%. Regarding urinary status, most of the patients were oliguric (88.9%). 68% of patients had acute renal failure and 99.3% of patients had chronic renal failure. The mean URR was 63 ± 10.4% with a median of 64. In 45.9% of patients, adequacy of dialysis was desirable. Besides, the most common cause of ESRD was attributed to HTN in 49.8%, and DM in 27.4%.

There was a significant negative association between URR and BMI (r = -0.155, P = 0.005). Adequacy of dialysis was significant in terms of BMI level (P = 0.005), which

Table 1. Patients' characteristics (n=344)

Variable	Level	N	%
Gender	Female	147	44.5
	Male	183	55.4
BMI (kg/m^2)	Underweight	8	2.5
	Normal	189	58.9
	Over weight	78	24.3
	Obese	46	14.3
Educational level	Primary	58	29.4
	Under diploma	56	28.4
	Diploma	67	34
	University	16	8.1
Marital status	Single	13	6.7
	Married	175	90.2
	Other	6	3.1
Urinary status	Oliguria	112	88.9
	Anuria	14	11.1
Diagnosis	Acute renal failure	2	68
	Chronic renal failure	290	99.3
ESRD cause	DM	88	27.4
	HTN	160	49.8
	GMN	11	3.4
	Unknown	33	10.3
	PKD	20	6.2
	Other	9	2.8
Blood type	O $^+$	119	36.4
	O $^-$	19	5.8
	A $^+$	91	27.8
	A $^-$	19	5.8
	B $^+$	62	18.9
	B $^-$	9	2.7
	AB $^+$	8	2.4
Dialysis adequacy (URR)	No	186	54.1
	Yes	158	45.9

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

Table 2. Mean dialysis adequacy (URR) in terms of laboratory testes

Parameter	Level	Mean	SD	Median	*P* value
Hemoglobin level (g/dL)	Low	63.8	10.2	65	0.484
	Normal	62.6	11.02	64	
	High	60.5	9.65	61.5	
Calcium (mg/dl)	Low	59	12.01	60	<0.001
	Normal	64.47	10.07	65	
	High	64.86	5.93	66	
Phosphorous (mg/dL)	Low	62.5	9.54	63.5	0.346
	Normal	63.72	10.53	65	
	High	61.62	11	64	
Albumin (g/dL)	Low	58	17.65	59.5	0.198
	Normal	62.88	9.47	64	
	High	-	-	-	
Uric acid (mg/dL)	Low	66	-	66	0.198
	Normal	63.63	9.74	64	
	High	60.56	12.13	63	
Vitamin D (ng/mL)	Lake	63.83	6.43	66	0.677
	Insufficient	60.8	11.2	62	
	Normal	63.3	8.86	63	
	High	57.6	10.83	59	
Sodium (mEq/L)	Low	70	-	70	0.594
	Normal	63.2	10.5	64	
	High	66.5	13.4	66.5	
Potassium (mEq/L)	Low	62.7	9.8	63.5	0.452
	Normal	63.67	10.2	65	
	High	60.8	11.8	63	
Parathyroid hormone (pmol/L)	Low	62.7	13.26	64	0.618
	Normal	63.3	12.6	66	
	High	62.47	8.22	64	

* Significant at a level of 0.05.

showed the mean URR was high in underweight patients. According to results of weight, the relation of URR index with pre-dialysis (r = -0.339, $P < 0.001$), and post-dialysis (r = -0.349, $P < 0.001$) was significant. Moreover, it was related to weight changes from pre- to post-dialysis (r = 0.166, $P = 0.002$). There was a significant association between the length of the time patients underwent dialysis (in year) and dialysis adequacy by URR (r = 0.125, $P = 0.023$). Patients with normal calcium levels had significantly higher URR adequacy than patients with abnormal calcium levels ($P < 0.001$; Table 2).

According to the results that is illustrated in Table 3, URR was inversely associated with blood pressure before and after dialysis ($P < 0.05$).

Furthermore, there was no significant relationship between dialysis adequacy (URR) and the type of vascular access [AV fistula, CVC, and graft] ($P = 0.217$; Table 4).

Discussion

Chronic kidney disease is one of the worldwide health problems. The incidence of chronic renal failure is 242 cases per million people in the world, and nearly 8% of them are added to the population each year (18). Therefore, one of the most important treatments to improve the condition of patients with chronic renal failure is hemodialysis (19). An effective dialysis can increase the quality of life of patients by reducing the complications of kidney failure. Although many parameters including electrolyte and fluid balance control are used clinically to diagnosis dialysis adequacy, the simplest to execute parameter is the URR criteria (20).

Table 3. Correlation of dialysis adequacy (URR) with vital signs

Parameter	Level	Correlation (r)	*P* value
Diastolic blood pressure	Before	-0.132	0.014*
	After	-0.154	0.004*
Systolic blood pressure	Before	-0.155	0.004*
	After	-0.212	0.000*
Blood temperature	Before	-0.089	0.103
	After	-0.107	0.051
Respiratory rate	Before	0.031	0.574
	After	0.07	0.207
Pulse rate	Before	0.072	0.189
	After	0.024	0.669

* Significant.

Table 4. Mean of dialysis adequacy (URR) in terms of the type of vascular access

Parameter	Type	Mean	SD	Median	*P* value
Vascular access	AV fistula	64	10.1	65	0.217
	CVC	62.9	10.3	64	
	Graft	60.7	13.8	63	

CVC, Central venous catheter.

The results of the present study showed that the mean URR was 63±10.4%, and the desirable adequacy of dialysis was reached in 45.9%. Previous evidence from Iranian studies reported wide variation ranging from URR index values (16,21,22). Based on recent study, targeting a URR ≥0.67 provides a simplified means of assessing adequacy of intermittent hemodialysis in patients with acute kidney injury. Moreover, their results suggest that URR, which may be more simply calculated than Kt/V, is suitable for calculation of delivery of small solute clearance (23). According to some studies, the most common complication post dialysis is the occurrence of hypotension. Though, many dialysis patients represented HTN with higher mortality (24–26).

According to other results of this study, there was a significant and inverse association between URR criteria and vital sign, and likewise between URR and BMI (R: -0.155). URR was related to weight changes from pre- to post-dialysis (R: 0.166). This finding suggests that the biographical characteristics of the individual can affect the adequacy of dialysis in addition to measuring it based on dialysis machines, which was similar to the study by Chang et al (27). Results of our study showed a significant association between the length of the time patients underwent dialysis and adequacy of dialysis based on URR (R: 125). It has been shown that there is a direct correlation between the dialysis adequacy with the number of dialysis sessions per week (28). Besides, it has been reported that patients who receiving frequent hemodialysis have better health quality compared to patients receiving conventional hemodialysis (29). This research was consistent with the current study. One strength of our study was its multicenter design. Besides, one of the main results that discriminated our study from previous research was the URR criterion was significantly associated with calcium level, so that patients with a normal calcium level had more dialysis adequacy (URR).

Conclusion

These findings suggested to provide treatment strategies to enhance the efficiency of dialysis adequacy. Besides, it seems to be necessary an effort to educate ESRD patients and nurses involved in dialysis to increase their awareness and reduce dialysis complications.

Limitations of the study

Limitation of our study were referred to limited study population, lack of follow-up of patients to determine the causes of poor quality dialysis.

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Authors' contribution

Conceptualization: SSM and MY.
Data curation: SSM and MY.
Methodology: MY and HSF.
Validation: HSF and SSM.
Investigation: HSF and SSM.
Formal analysis: SSM, MY and AH.
Resources: SSM, MY and AH.
Writing–original draft preparation: SSM and MY.
Writing–review and editing: SSM and HSF
Visualization: SSM and HSF
Project administration: SSM and HSF.
Supervision: SSM.

Conflicts of interest

No potential conflict of interest was reported by the authors.

Ethical issues

The research followed the tenets of the Declaration of Helsinki. The Ethics Committee of Guilan University of Medical Sciences approved this study (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#96072902). Besides, ethical issues (including plagiarism, data fabrication, double publication) have been completely observed by the authors.

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