

USE OF OPTIMAL DIALYZER FOR HEMODIALYSIS PROCEDURE AMONG PATIENTS ON MAINTENANCE HEMODIALYSIS THRICE WEEKLY

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ABSTRACT

Background: Hemodialysis adequacy is essential for effective removal of uremic solutes and is commonly assessed using urea reduction ratio (URR) and Kt/V.

Objective: To determine Kt/V, URR, and one-month mortality among patients receiving maintenance hemodialysis three times weekly through an optimal dialyzer.

Methodology: The descriptive case series was carried out in the Dialysis Unit of Department of Nephrology at Sir Ganga Ram Hospital, Lahore, from 15th January to 15th June 2017. Patients with end stage renal disease (ESRD) on maintenance hemodialysis (MHD) were consecutively recruited from the center for a total of 170 patients aged 18-65 years. Pre and post dialysis urea measurements were performed and expected clearance, URR and Kt/V were calculated. Patients were followed up for a month for mortality. The data were analyzed with SPSS version 23.0.

Results: Among 170 patients, 127 (74.70%) were male and 43 (25.30%) were female, with a mean age of 43.59 ± 12.83 years. The mean expected clearance was 196.32 ± 39.16 , mean URR was $66.74 \pm 9.26\%$, and mean Kt/V was 1.54 ± 0.43 . URR $\geq 65\%$ was achieved by 91 (53.53%) patients, while Kt/V ≥ 1.3 was achieved by 116 (68.24%). URR was significantly associated with gender ($p < 0.001$) and dialysis duration ($p = 0.018$), while Kt/V was significantly associated with gender ($p = 0.032$) and dialysis duration ($p = 0.041$). No mortality occurred during one-month follow-up (0/170, 0.00%).

Conclusion: Routine monitoring of URR and Kt/V can help assess delivered dialysis adequacy and identify patients requiring optimization of dialysis therapy.

KEYWORDS: Hemodialysis; dialysis adequacy; Kt/V; urea reduction ratio; mortality; end-stage renal disease; dialyzer

INTRODUCTION

Hemodialysis (HD) is one of the major renal replacement therapies (RRT) used for advanced renal failure, wherein metabolic waste products like urea, excess body water are removed from the body with the help of extracorporeal circulation. The uremic solute clearance and dialysis adequacy are critical factors to assess in patients undergoing maintenance hemodialysis, as insufficient dialysis clearance may result in poor clinical outcomes, such as cardiovascular problems and death [3]. Several factors affect the effectiveness of a dialysis session such as the characteristics of the dialyzer, membrane permeability, blood and dialysate flow rates, and the duration of the dialysis session and dialysis dose delivered [4,5].

Both the Kt/V and the urea reduction ratio (URR) are used as a standard way of assessing dialysis adequacy. Kt/V is a dimensionless parameter that is defined by the dialyzer clearance of urea (K), dialysis treatment time (t) and the urea distribution volume (V) [6,7]. The URR is the percentage decrease in blood urea level after a dialysis session, which is obtained from the pre- and post-dialysis urea level [8]. URR is widely used in the routine dialysis practice owing to its simplicity and easy calculation. While Kt/V is a more complete assessment of delivered dialysis dose, URR is tightly related to Kt/V and can be used as a practical measure of dialysis adequacy [9].

In patients undergoing conventional maintenance thrice weekly dialysis, the prescription of the prescribed dialysis dose is not the only factor influencing the delivery of adequate dialysis; the length of dialysis, vascular access performance, blood flow, dialyzer efficiency, and compliance with scheduled dialysis sessions are also important [10,11]. Failure to receive or receive dialysis as scheduled can lead to buildup of uremic toxins and fluid, which can lead to increased morbidity and mortality [12]. Variations in patient characteristics, dialysis duration, treatment parameters, and dialyzer performance have been reported to contribute to the wide range of URR and Kt/V found in patients on maintenance hemodialysis therapy (MHD) [13,14].

Because assessment of Kt/V and URR can be used to evaluate the delivered dose of dialysis along with short-term mortality, a clinical assessment framework has been provided to assess the delivered dialysis.

Research Objective

To determine Kt/V, urea reduction ratio (URR), and the frequency of mortality among patients receiving maintenance hemodialysis three times weekly through an optimal dialyzer.

MATERIALS AND METHODS

Study design and Setting

Dialysis adequacy (Kt/V and urea reduction ratio (URR)) and one-month mortality of patients on maintenance hemodialysis were evaluated using a descriptive case series design. This study was carried out in the Dialysis Unit of department of nephrology at Sir Ganga Ram hospital in Lahore.

Duration of Study

The study was conducted over a period of five months, from January 15, 2017, to June 15, 2017.

Sample Size and Technique

The sample size of 170 patients was determined with a 95% confidence interval and a 7% margin of error, assuming an end-stage renal disease (ESRD) urea reduction ratio (URR) of 68% amongst ESRD patients. Consecutive sampling, which is a type of non-probability sampling, was utilized. All qualified patients who were found to have the inclusion/exclusion criteria were subsequently enrolled in the study until the necessary number of patients was reached.

Inclusion and Exclusion Criteria

The inclusion criteria were patients who are undergoing maintenance hemodialysis at the Dialysis Unit of Sir Ganga Ram Hospital and having end-stage renal disease (ESRD). All patients aged 18 to 65 years of both sexes were included. Patients who had been on peritoneal dialysis, had active cardiovascular disease, terminal disease or acute kidney injury less than 3 months were excluded.

Data Collection Procedure

Total 170 patients with ESRD on maintenance hemodialysis fulfilling the inclusion criteria were enrolled from the Dialysis Unit of department of Nephrology of Sir Ganga Ram Hospital Lahore. All participants gave written informed consent prior to participation. The researcher in consultation with the relevant nephrology experts and hospital staff developed a structured proforma. This was to obtain biological data, such as age and sex, and clinical and dialysis-related data. Blood samples were drawn pre- and post- the index hemodialysis session. Pre-dialysis sample was taken right before starting dialysis. To minimize the potential effect of saline and heparin dilution, in patients with vascular access catheter in place, an initial 5 mL sample was drawn and discarded and a second sample was drawn for BUN estimation. During post dialysis evaluation, blood flow was kept at the prescribed rate and dialysate flow was stopped for three minutes. After dialysis, the blood was then drawn from the arterial sampling port, about 3 minutes after dialysis, to minimize the effect of access recirculation. The expected urea clearance (K) for each patient was calculated. The permeability coefficient (KoA) of the dialyzer membrane was calculated by the blood flow rate (Qb) and dialyzer blood-water urea clearance (K) from the relevant nomogram used to calculate dialyzer efficiency (KoA). The study proforma was completed with the relevant dialysis parameters and laboratory measurements. Kt/V and urea reduction ratio (URR) were computed according to the formulas provided. Patients were followed-up for 1 month and mortality was observed.

Data Analysis Procedure

The collected data were later entered and analysed by Statistical Package for the Social Sciences (SPSS), version 23.0. Blood flow rate, URR, Kt/V and expected clearance rate were reported as mean $\pm$ standard deviation values. Qualitative variables, such as gender, mortality were presented as frequencies and proportions. To look for potential effect modification, data were stratified by age, gender, and duration of dialysis. After stratification the Chi-square-test was used to compare categorical variables. A p value of <0.05 was deemed as statistically significant.

Ethical Considerations

The study was conducted after obtaining ethical approval from the institutional ethics committee of Sir Ganga Ram Hospital, Lahore. All participants gave informed written consent and confidentiality was ensured during the study. Participants were free to withdraw at any time without compromising medical care and got to decide if they wanted to participate.

RESULTS

Table 1 shows that most participants were male (127, 74.70%), while 43 (25.30%) were female. The mean age was 43.59 ± 12.83 years (range: 18–65), with the largest proportion aged 46–65 years (44.70%). Regarding dialysis duration, 47 (27.60%) had received dialysis for >4 years. The mean expected clearance (K) was 196.32 ± 39.16 (range: 119–366), while mean URR was $66.74 \pm 9.26\%$ (range: 46–89) and mean Kt/V was 1.54 ± 0.43 (range: 0.84–2.97).

Table 1. Summary of demographic and dialysis-related characteristics

Variable	Category / Measure	n (%) / Mean $\pm$ SD (Range)
Gender	Male	127 (74.70%)
	Female	43 (25.30%)
Age group (years)	18–30	30 (17.60%)
	31–45	64 (37.60%)
	46–65	76 (44.70%)
	Overall	43.59 $\pm$ 12.83 (18–65)
Duration of dialysis	Up to 1 year	33 (19.40%)
	2–3 years	49 (28.80%)
	3–4 years	41 (24.10%)
	>4 years	47 (27.60%)
Expected clearance (K)	Overall	196.32 $\pm$ 39.16 (119–366)
URR (%)	Overall	66.74 $\pm$ 9.26 (46–89)
Kt/V	Overall	1.54 $\pm$ 0.43 (0.84–2.97)

Table 2 shows that URR differed significantly by gender, with 45.67% of males achieving URR $\geq$ 65% compared with 76.74% of females ($\chi^2 = 10.46$, $p < 0.001$). No significant association was observed between URR and age group ($\chi^2 = 0.92$, $p = 0.631$). URR was significantly associated with duration of dialysis ($\chi^2 = 10.06$, $p = 0.018$), with URR $\geq$ 65% observed in 70.21% of patients dialyzed for >4 years.

Table 2. Stratification of URR according to gender, age group, and duration of dialysis

Stratification variable	Category	URR <65%, n (%)	URR $\geq$ 65%, n (%)	Test value	p-value
Gender	Male	69 (54.33%)	58 (45.67%)	$\chi^2 = 10.46$	<0.001
	Female	10 (23.26%)	33 (76.74%)		
Age group (years)	18–30	12 (40.00%)	18 (60.00%)	$\chi^2 = 0.92$	0.631
	31–45	29 (45.31%)	35 (54.69%)		
	46–65	38 (50.00%)	38 (50.00%)		
Duration of dialysis	Up to 1 year	21 (63.64%)	12 (36.36%)	$\chi^2 = 10.06$	0.018
	2–3 years	22 (44.90%)	27 (55.10%)		
	3–4 years	22 (53.66%)	19 (46.34%)		
	>4 years	14 (29.79%)	33 (70.21%)		

Note: Chi-square test was used. Percentages are calculated within each category. Test statistics are χ^2 values.

Table 3 shows that Kt/V $\geq$ 1.3 was achieved by 63.78% of males and 81.40% of females, with a significant association between gender and Kt/V ($\chi^2 = 4.60$, $p = 0.032$). The association between age group and Kt/V was not statistically significant ($\chi^2 = 5.88$, $p = 0.053$). Kt/V was significantly associated with dialysis duration ($\chi^2 = 8.28$, $p = 0.041$), with 82.98% of patients receiving dialysis for >4 years achieving Kt/V $\geq$ 1.3.

Table 3. Stratification of Kt/V according to gender, age group, and duration of dialysis

Stratification variable	Category	Kt/V <1.3, n (%)	Kt/V $\geq$ 1.3, n (%)	Test value	p-value
Gender	Male	46 (36.22%)	81 (63.78%)	$\chi^2 = 4.60$	0.032
	Female	8 (18.60%)	35 (81.40%)		
Age group (years)	18–30	4 (13.33%)	26 (86.67%)	$\chi^2 = 5.88$	0.053
	31–45	24 (37.50%)	40 (62.50%)		
	46–65	26 (34.21%)	50 (65.79%)		
Duration of dialysis	Up to 1 year	14 (42.42%)	19 (57.58%)	$\chi^2 = 8.28$	0.041
	2–3 years	15 (30.61%)	34 (69.39%)		
	3–4 years	17 (41.46%)	24 (58.54%)		
	>4 years	8 (17.02%)	39 (82.98%)		

Note: Chi-square test was used. Percentages are calculated within each category. Test values are χ^2 statistics.

Figure 1 shows that no mortality was recorded during the one-month follow-up; all 170 patients (100.00%) survived.

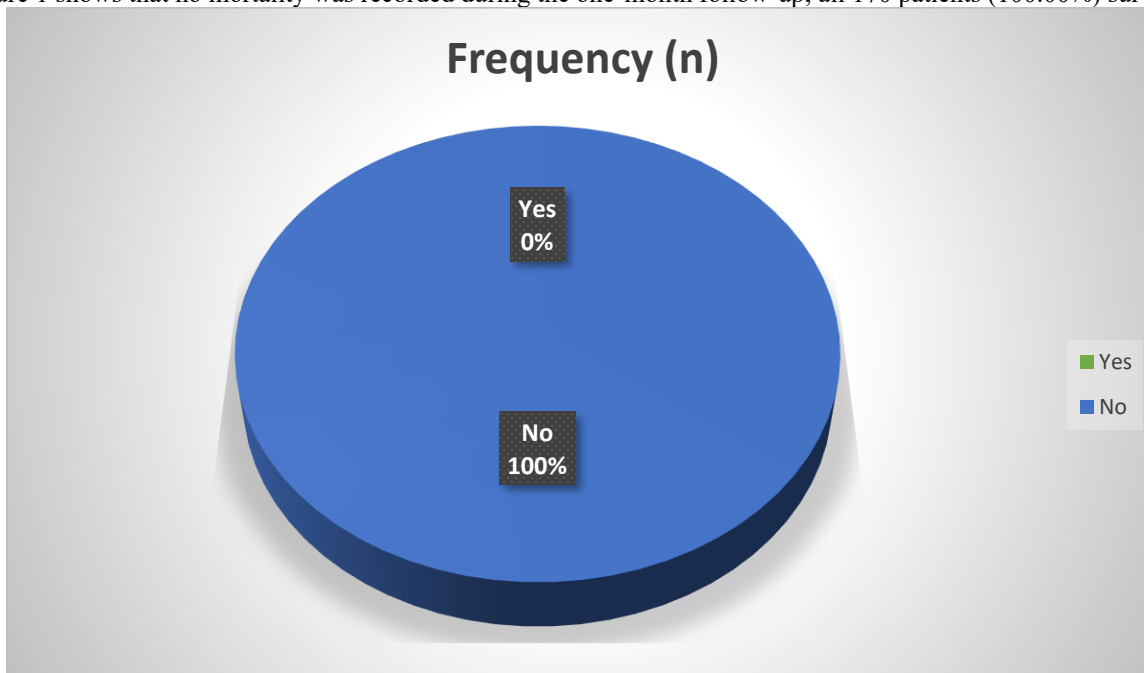


Figure 1. Frequency distribution of mortality

DISCUSSION

A total of 170 patients in maintenance haemodialysis were evaluated, the mean age was 43.59 ± 12.83 years and 74.70% of them were male, and 25.30% female. The mean expected urea clearance (K) was 196.32 ± 39.16 , while mean URR and Kt/V were $66.74 \pm 9.26\%$ and 1.54 ± 0.43 , respectively. Overall, this cohort seems to have a satisfactory delivered dialysis dose. In contrast, the previous study reported significantly lower mean Kt/V (1.06 ± 0.05) and URR ($54.4 \pm 19.3\%$) for 64 Palestinian patients and only 39.1% and 34.4% of patients reached the target of Kt/V and URR, respectively [15]. The same, a systematic review of 21 Iranian studies revealed that only 36.3% of patients had Kt/V >1.2 and 28.8% had URR >65 , indicating a wide range of dialysis adequacy across countries [16]. In the present study, the difference of gender was found to be statistically significant with respect to URR, $\chi^2 = 10.46$, $p < 0.001$. 76.74% of females met the criteria of URR $\geq 65\%$, while 45.67% of males met the criteria of URR $\geq 65\%$. This is similar to the results of Somji et al. (2020), who found that men were at higher risk for inadequate dialysis by Kt/V, but this was not independently significantly after adjusting [17]. Part of the difference we found in our study could be due to size difference and difference in urea distribution volume which can affect normalized dialysis dose (NDD) measurements. Importantly, a systematic review that included 31 studies and a total of >1.4 million patients identified evidence of sex-related differences in the association of dialysis adequacy with outcomes, but there was significant heterogeneity among studies [18].

In this study, there was no significant association between URR and age group ($\chi^2 = 0.92$, $p = 0.631$). The proportion achieving URR $\geq 65\%$ was 60.00% among patients aged 18–30 years, 54.69% among those aged 31–45 years, and 50.00% among those aged 46–65 years. This is similar to previous research study by other group that was unable to find significant association between dialysis adequacy and age [15]. Likewise, Somji et al., (2020) didn't find age to be an independent predictor of poor dialysis [19]. These results indicate that chronological age may not be the most important parameter, as treatment-related factors like the characteristics of the dialyzer, time of treatment, blood-flow rate and dialysis time may be more significant.

In the analysis of the data, the duration of dialysis was found to be significantly related to URR ($\chi^2 = 10.06$, $p = 0.018$). Of those who were dialyzed for <1 year, 36.36% achieved URR $\geq 65\%$ while 70.21% of those with dialysis duration >4 years achieved URR $\geq 65\%$. This is in contrast to the systematic review conducted by Barzegar et al., (2016) which found that inadequate dialysis was often due to short treatment duration, and the filter used was not appropriate, or that the blood flow rate was low [16]. It is therefore possible that our finding could be a result of better adaptation to maintenance dialysis or more stable vascular access or optimized treatment parameters in the patients with the longest dialysis exposure, but these were not directly measured and should be interpreted with caution.

For Kt/V, the mean value was 1.54 ± 0.43 , and significant associations were observed with both gender ($\chi^2 = 4.60$, $p = 0.032$) and duration of dialysis ($\chi^2 = 8.28$, $p = 0.041$). Sixty-three.78% of males and 81.40% of females had Kt/V ≥ 1.3 , which rose from 57.58% in patients dialyzed for ≤ 1 year to 82.98% in those dialyzed for >4 years. These findings are contrary to what is reported by Somji et al., 2020, which reported an inadequate Kt/V for only 40.6% and male

sex was a factor that was associated with inadequate dialysis in univariate analysis [17]. They are also higher than the mean Kt/V of 1.40 reported by Aghsaiefard et al., (2022) in 128 patients [20]. These differences might be associated with patient differences, dialysis treatment prescription, dialyzer performance, and dialysis treatment practice among centers.

Lastly, during the 1-month follow-up, there were no deaths in the present study (0/170, 0.00%). The short follow-up period and small sample size should be taken into account when interpreting this finding. Aghsaiefard et al., (2022) observed that during significantly longer follow-up, 9 deaths occurred out of 128 patients, and there was a significant relationship between Kt/V and mortality ($p = 0.001$) [20]. Previous study of 18,242 maintenance hemodialysis patients followed for a median of 5.2 years reported that increased dialysis adequacy was associated with decreased all-cause mortality [21]. Therefore, it is important to note that lack of mortality in our cohort does not mean there is no relationship between dialysis adequacy and mortality, rather larger prospective studies with more follow-up are needed to reliably assess this outcome.

STRENGTHS AND WEAKNESSES

One of the best features of this study is the systematic evaluation of dialysis adequacy based on universally accepted guidelines, such as the urea reduction ratio (URR), Kt/V, and expected clearance, stratified by gender, age, and dialysis duration. Given the fact that the consecutive sampling method minimized the selective recruitment of participants and standardized measurements of pre- and post-dialysis were used, a consistent basis for judging dialysis performance was established. There are some limitations in the study, however. The findings from this descriptive case-series study with a single center at Sir Ganga Ram Hospital, Lahore might not be generalizable to other dialysis patient cohorts. Selection bias can also occur with non-probability sampling. The relatively short time of study and follow-up limit our assessment of longer-term outcomes, such as mortality. Besides, dialysis adequacy could be affected by other factors that were not fully assessed, including vascular access characteristics, blood-flow rate, dialysate flow, body composition, nutritional status, and comorbidities.

CONCLUSION

The results of this study showed that dialysis adequacy could be well evaluated by routinely available parameters like URR and Kt/V, which were found to vary between the genders as well as with the duration of dialysis, but were not found to differ significantly with age. The results suggest that dialysis dose needs to be monitored regularly and the patients on maintenance hemodialysis evaluated individually. Treatment adequacy can be evaluated consistently to identify those who may need optimization of the dialysis prescription; this may contribute to improving the quality of RRT.

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