Original Article

Hemodialysis Adequacy in Chronic Hemodialysis Patients: Evaluating Urea Reduction Ratio and Associated Factors in Our Population

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ABSTRACT

OBJECTIVE: To evaluate hemodialysis adequacy using URR and identify factors influencing it.
METHODOLOGY: This single-centre, cross-sectional, prospective study was conducted at a large hospital in Pakistan from June 2022 to July 2023. Blood samples were taken for hemoglobin, serum albumin, and pre- and post-dialysis blood urea nitrogen (BUN) levels. Caloric intake was assessed using a 2-day dietary questionnaire, and BMI was calculated. The Urea Reduction Ratio (URR) was computed using the slow-pump technique, applying the URR formula.
Data were entered into SPSS version 22. A p-value of <0.05 was considered significant. Z-scores and chi -square tests were used for statistical analysis.
RESULTS: A total of 193 participants were enrolled in the study. Participants' mean (SD) age was 46 (12.9) years. 111 (58%) were male, and 82 (42%) were female. The mean (SD) body mass index (BMI) was 21.6 (4.02) kg/sqM. 63.2% of the study population had a URR > 65%. The mean URR was 69.2 (10). 68 (35.2%) males achieved URR > 65% compared to 54 (27.9%) females (p-value: 0.513). The middle-aged group had the most significant number of patients with URR > 65%, and the old-age group had the fewest. (p-value: 0.00001).
CONCLUSION: Dialysis prescription and age have a statistically significant impact on URR, whereas gender does not.

KEYWORDS: adequacy, urea reduction ratio (URR), dialysis, end-stage renal disease (ESRD), body mass index (BMI).

INTRODUCTION

Renal transplant and dialysis are primary treatments for End-Stage Renal Disease (ESRD)[1]. Hemodialysis (HD) is used in 90% of dialysis patients worldwide who have not received a transplant[2]. The goal of hemodialysis is to maintain physical health and prevent complications from uremia, such as anemia, malnutrition and bone mineral disorders[3].
The global burden of ESRD is rising, with 100 individuals per million suffering from dialysis-dependent renal failure[4]. However, accurate statistics on the burden of ESRD in Pakistan are lacking. Dialysis adequacy is key to treatment success and can be assessed using urea-based methods like Kt/V and URR (urea reduction ratio)[5]. For thrice-weekly hemodialysis, a URR of >65% is considered adequate, with increased morbidity and mortality associated with a URR <65%[6]. Maintaining dialysis adequacy is challenging, and literature reports varying adequacy levels[7].

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The primary outcome of the study was to evaluate hemodialysis adequacy using URR and to identify factors influencing it; the secondary outcome was to assess therapeutic goals of adequate dialysis, including nutritional status, anemia, and maintaining a healthy BMI.

METHODOLOGY

This single-centre, cross-sectional, prospective study was conducted at a large hospital in Karachi, Pakistan, after ethical approval. The study ran from June 2022 to July 2023. Patients aged 18 or older with end-stage renal disease (ESRD) receiving dialysis were included, provided they gave informed consent. Exclusion criteria included conditions affecting serum urea levels, such as liver disease or malabsorption syndrome. Data were collected by the principal investigator using a manual proforma. Blood samples were taken for hemoglobin, serum albumin, and pre- and post-dialysis blood urea nitrogen (BUN) levels. Caloric intake was assessed using a 2-day dietary questionnaire, and BMI was calculated as weight (kg) divided by height (m²). Sample size was calculated with a 95% confidence level, a 43% prevalence of URR > 65% [8], and a 7% margin of error.
Computing Urea Reduction Ratio (URR): BUN levels were measured pre- and post-dialysis in patients on hemodialysis. The pre-dialysis sample was taken from the arterial needle before saline or heparin

administration or from a central venous catheter after withdrawing 10 mL of blood. Post-dialysis samples were collected using a slow-flow technique. The pump speed was reduced to 100 ml/min for 20 seconds, and a sample was taken from the arterial needle after clamping both ports. Samples were analyzed using the colorimetric method at the central biochemistry lab. URR was calculated using:

URR = 100 × (1 - [Ct / Co])

Where Ct is post-dialysis BUN and Co is pre-dialysis BUN.

Statistical Analysis: Data were entered into SPSS version 22. Frequencies and percentages were calculated for gender and comorbidities. A p-value of <0.05 was considered significant. Z-scores and chi-square tests were used for statistical analysis.

RESULTS

A total of 193 participants were enrolled in the study. Participants' mean (SD) age was 46(12.9) years. Of these, 111(58%) were male and 82(42%) were female. The mean (SD) height of the study population was 163(15.6) cm, the mean (SD) weight was 58(13) kg, and the mean (SD) body mass index (BMI) was 21.6(4.02). A total of 116 (60.1%) patients were receiving hemodialysis 3 times per week, and 77 (39.9%) were receiving hemodialysis 2 times per week. Among the participants, 179(97.2%) had an arteriovenous fistula (AVF), and 14(7.3%) had a permanent double-lumen catheter (Permacath) for angio-vascular access. The hemodialysis prescription was a blood flow rate (BFR) of 350 ml/min in 152 (78.8%) patients and 300 ml/min in 41 (21.2%) patients. The rest of the prescription was similar across all patients, consisting of a dialysis flow rate of 500 ml/min, a polysulphone high-flux dialyzer of 1.8 m², and an ultrafiltration rate adjusted to the dry weight of the individual patient, ranging from 1.5 to 2 L per session. Each hemodialysis session lasted for an average of 4 hours as per KDOQI recommendations. (**Table I**)

34% of the study population had diabetes mellitus (DM), 57.7% had hypertension (HTN), 7.2% had cerebrovascular accidents, and 12.4% had ischemic heart disease as co-morbid conditions (**Figure 1**).

106(54.9%) patients had anemia, with a mean hemoglobin level of 10.3(1.7) gm/dL. The mean (SD) albumin level was 3.6 (0.55) mg/dL, and 34% of study participants had mild hypoalbuminemia, with serum albumin levels ranging from 3.5 mg/dL to 2.5 mg/dL. The mean pre-dialysis BUN was 94.4(45) mg/dL, and post-dialysis BUN was 28.8(15.9) mg/dL (**Table II**).

63.2% of the study population had a URR > 65%. The mean URR was 69.2(10). Males outnumbered females, with 68(35.2%) males achieving URR > 65% compared to 54(27.9%) females (p-value: 0.513). The middle-aged group had the highest number of patients with URR > 65% (62 [31.6%]), followed by the young age group (45 [23.3%]) and the old age group (15 [7.7%]) (p-value: 0.00001). In patients with URR > 65%, adequate caloric intake was observed in 98 (50.8%) of patients, whereas only 38(19.7%) with URR < 65% had adequate caloric intake (p-value < 0.001). The mean BMI of 21.5 kg/m² was found in 111 (57.5%) patients with URR > 65%, while only 42 (21.8%) patients with URR < 65% had a mean BMI of 21.5 kg/m² (p-value < 0.00006). Hypoalbuminemia was observed in 46(23.8%) patients with URR > 65%, and in 21(10.9%) patients with URR < 65% (p-value: 0.207). Anemia was found in 78(40.4%) patients with URR > 65%, while 28(14.8%) patients with URR < 65% had anemia (p-value: 0.012) (**Table III**).

Table I: Descriptive statistics

Variable	Statistics
Age (years)	46 (12.9)
Age below 40 (young age) (n)	66
40 to 60 (middle age) (n)	81
More than 60 (old age) (n)	46
Gender	
Male (n)	111 (58%)
Female (n)	82 (42%)
Height (cm)	163 (15.6)
Weight (kg)	58 (13)
BMI (kg/m²)	21.6 (4.02)
Frequency of hemodialysis (per week)	
Twice/week	77 (39.9%)
Thrice/week	116 (60.1%)
Blood flow rate (BFR) of 350 ml/min	152 (78.8%)
Blood flow rate (BFR) of 300 ml/min	41 (21.2%)
Hemodialysis access	
Arteriovenous fistula (AVF) (n)	179 (97.2%)
Permacath (n)	14 (7.3%)

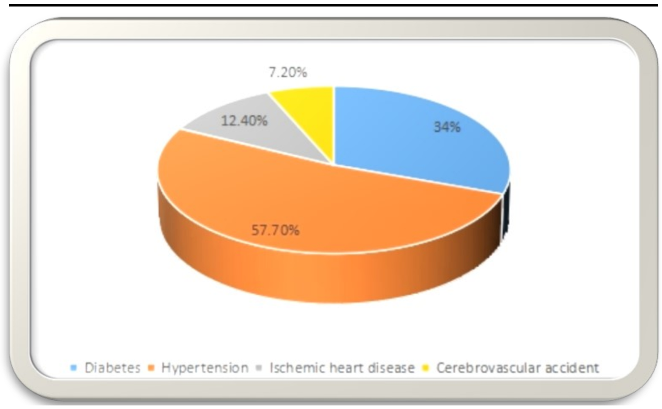

Figure 1: Frequency distribution of comorbidities among the study population

Table II: Laboratory parameters and hemodialysis prescription

Variable	Value
Hemoglobin (gm/dL)	10.3 (1.7)
Anemia (n)	106 (54.9%)
Albumin (gm/dL)	3.6 (0.55)
Pre-dialysis BUN (mg/dL)	94.4 (45)
Post-dialysis BUN (mg/dL)	28.8 (15.9)

BUN = blood urea nitrogen

Table III: Statistics of URR

Variable	URR > 65%	URR<65%	p-value
Male (n)	68 (35.2%)	43 (22.2%)	0.513
Female (n)	54 (27.9%)	28 (14.5%)	
Young age (n)	45 (23.3%)	21 (10.9%)	0.00001
Middle age (n)	62 (31.6%)	19 (9.8%)	
Old age (n)	15 (7.7%)	31 (16%)	
Anemia (n)	78 (40.4%)	28 (14.8%)	0.012
Hypoalbuminemia (n)	46 (23.8%)	21 (10.9%)	0.207
Adequate caloric intake (n)	98 (50.8%)	38 (19.7%)	<0.001
Mean BMI (21.5 kg/m²)	111 (57.5%)	42 (21.8%)	<0.001

DISCUSSION

Hemodialysis after renal transplant is an effective treatment for patients with chronic kidney disease (CKD)[9]. This therapy is considered a means to prolong survival in patients with CKD. Various techniques are available to study the adequacy of dialytic therapy, with urea kinetics being the most widely used tool for this assessment[10]. Several patient -related and treatment-related factors have been identified that alter the quality of dialysis therapy[11], including the socioeconomic condition and nutritional status of the patient[12]. We evaluated such factors in our population using the urea reduction ratio (URR) to assess dialysis adequacy. Dialysis prescription, as a treatment-related factor, and the gender and age of the patient, as patient-related factors, have been identified as influencing dialysis adequacy. According to the Kidney Disease Outcomes Quality Initiative (KDOQI) recommendations, URR > 65% is considered adequate for dialysis[13]. The mean pre-dialysis BUN was 94.4 (45) mg/dL, and the mean post -dialysis BUN was 28.8 (15.9) mg/dL. The URR ranged from 38.8% to 95.5%, with a mean URR of 69.2% (10), which is better than the reported mean URRs of 25.24±15.59% in one study from Nepal[14] and 65.3% in another study[15]. Regarding the primary outcome of our study, 63.2% of the study population achieved a URR > 65%, while the remaining 39.8% of patients had a URR< 65%. The literature review reveals a much lower figure for URR > 65%, being 34.3% [16] in one study and 23% [8] in another. One reason for the relatively better results in our population appears to be associated with the optimal dialysis prescription (KDOQI recommendations) [17].

In our study, hemodialysis was prescribed thrice per week for 116 (60.1%) patients, with a blood flow rate of 300-350 ml/min, using a polysulphone high-flux dialyzer with a surface area of 1.8 m² and a dialysis flow rate of 500 ml/min. A thrice-per-week hemodialysis regimen has a positive impact on survival[18]. Patient-related factors that can reduce dialysis efficacy were present in the study participants. 34% of patients had DM, and 57.7% had HTN. In our study, AVF was used for vascular access in 97.2% of patients, which is higher than the 66% reported in a similar study from Pakistan[16]. This difference may reflect improved vascular access practices, which are known to influence dialysis adequacy. The presence of comorbidities can indirectly affect hemodialysis efficiency, notably by impairing AVF function and vascular access patency, as reported in previous studies[18,19].

The mean age of our population was 46(12.9) years, with the majority of the study population falling within the middle-aged group, similar to previous studies[20]. on subgroup analysis, 31.6% of patients in the middle age group had URR > 65%, 23.3% in the young age group, and only 7.7% in the old age group had URR > 65% (p-value: 0.00001). Males (111 [58%]) outnumbered females (82 [42%]) in our study, consistent with the fact that males undergo hemodialysis more frequently than females[21]. We did not observe a statistically significant effect of gender on URR. The mean URR in males was 68 (10.3), while in females it was 70.8 (9.6). A total of 68(35.2%) males and 54(27.9%) females had URR > 65% (p-value: 0.513). Treating anemia and maintaining a KDOQI-recommended hemoglobin level (11-12 gm/dL)[21] is one of the therapeutic targets for optimal dialysis[22,23]. The mean hemoglobin of our study population was 10.3 (1.7) gm/dL, and the prevalence of anemia in our study was statistically insignificant (106 [54.9%], p-value 0.21498). Among patients with URR > 65%, 78(40.4%) had anemia. Evaluating dietary intake in the dialysis population has prognostic value for long-term dialysis outcomes[24]. Uremia triggers an inflammatory response that worsens malnutrition, and the use of a dialyzer with poor membrane biocompatibility may be a contributing factor[25].

In our study, a biocompatible polysulphone high-flux dialyzer was used. Nutritional status was assessed using caloric intake and body mass index (BMI). In patients with URR > 65%, adequate caloric intake was found in 50.8% of patients, and these patients maintained a mean BMI of 21.5kg/m² in 57.5% of patients. In contrast, only 19.7% of patients with URR < 65% had adequate caloric intake, and 21.8% of patients maintained a mean BMI of 21.5 kg/m², with a statistically significant difference. These findings indicate a significant association between nutritional indicators and dialysis adequacy; however, due to the cross-sectional nature of our study, a causal relationship cannot be established. One study on dietary intake in dialysis patients undergoing hemodialysis with suboptimal prescriptions reported inadequate nutritional intake and a loss of appetite, leading to malnutrition in these patients[26,27].

Our study's mean serum albumin level was 3.6 mg/dL, with hypoalbuminemia observed in only a small number of patients (23.8%). When optimized, the dialysis prescription helps achieve dialysis goals.

Limitations: Our study has certain limitations. It has limitations of the generalizability of the findings due to single-centre data. The Kt/V parameter, as a marker of adequacy, was not implemented due to data unavailability. Assessment of dietary intake by recall is subject to recall bias. Future multicenter studies incorporating Kt/V and broader sociodemographic data are recommended to provide a more comprehensive evaluation of dialysis adequacy. Although logistic regression analysis could help identify independent predictors of dialysis adequacy (URR > 65%), our study design and sample size were not intended for predictive modeling. Future multicenter studies with larger samples are recommended to assess these predictors in a statistically robust manner.

CONCLUSION

Optimizing dialysis prescription, as suggested by KDOQI, is associated with achievement of the therapeutic goals of maintenance hemodialysis. Dialysis prescription is significantly associated with optimal URR. Males achieve greater URR when compared to females, but the impact of gender is statistically insignificant. Age in our population was associated with URR, and middle-aged patients achieved URR >65% more often.

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AUTHOR CONTRIBUTION

All authors contributed equally to all aspects of the research.

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