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Original Article

Evaluation of hemodialysis adequacy in patients with CKD in the hemodialysis unit at SBMCH, Barishal

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ABSTRACT

Background: *Chronic kidney disease (CKD) is a progressive loss in kidney function over a period of months or years. According to the World Health Organization (WHO) data published in 2018 Kidney Disease Deaths in Bangladesh reached 16,948 or 2.18% of total deaths. The age adjusted Death Rate is 14.83 per 100,000 of population ranks Bangladesh #94 in the world. Review other causes of death by clicking the links below or choose the full health profile.[1] In Bangladesh, chronic kidney diseases is one of the major problems. Albeit it has been considered arduous for poor to bring up the cost, they have to rely on this treatment in the final stage of renal diseases. Worldwide, hemodialysis constitutes the most common form of renal replacement therapy and many studies have shown strong correlation between Hemodialysis dose and clinical outcome measured by Kt/V.* ***Objectives:*** *The primary purpose of this cross sectional study is the evaluation of hemodialysis adequacy in patients with end-stage renal disease on maintenance of hemodialysis.* ***Methods and Martials:*** *This cross-sectional study was conducted on 55 patients in the Hemodialysis unit of Nephrology Department at Shere-e-Bangla Medical College and Hospital, Barishal (SBMCH). Study period was one year from January, 2020 to December, 2020. A questionnaire was prepared by the researcher considering the key variable like age, sex, presenting symptoms, clinical findings, associated medical conditions, investigations preoperative findings, outcome was verified by the guide. SpKt/V was used to assess the adequacy and URR of Hemodialysis. Statistical analysis was carried out for all collected data using SPSS 23, chi-square test and a logistic regression analysis. P-value was determined less than 0.05 which is statistical significant.* ***Results:*** *The proportion of patients receiving adequate hemodialysis among patients undergoing chronic hemodialysis based on URR was 34.3% and based on Kt/V was 40.6%. By Kt/V criteria, males had significantly a higher prevalence of inadequate hemodialysis (66.6% versus 47.4%, p value 0.047) but not by URR criteria (69.4% versus 57.1%, p value 0.138). Patients using a dialyzer surface area of less than 1.4 m^2 had significantly more inadequate hemodialysis as compared to those with dialyzer surface area ≥1.4 m^2 (68.8% versus 42.9%, p value 0.022, by URR criteria (85.7% versus 10%, p value 0.032, by Kt/V criteria). In Kt/V measures, patients who had hemoglobin of <10 g/ dl in the last month had significantly more inadequate hemodialysis as compared to those who*

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had hemoglobin of ≥10 g/dl. This association was not seen when using URR criteria (70.8% versus 61.3%, p value 0.201, by URR criteria) (69.8 versus 51.6%, p value 0.028, by Kt/V criteria). Our findings clearly showed a strong positive correlation between dialysis dose and Hemodialysis level, serum albumin level, normalized protein catabolic rate, and physical health. ***Conclusion:*** *Hemodialysis inadequacy is frequent in SBMCH and is associated with male gender, dialyzer surface area, and hemoglobin level. Hemodialysis adequacy was influenced by several factors such as duration and frequency of the dialysis session, patients' complaints, and well-functioning vascular access. Giving the correct hemodialysis dose could help improve hemodialysis adequacy.*

Keywords: *hemodialysis, inadequacy, outcomes, vascular access.*

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INTRODUCTION

Chronic kidney disease (CKD) has nearly doubled as a cause of death worldwide between 1990 and 2010 and was the 18th highest cause of death worldwide in 2010 [2]. Kidney disease is considered as a major public health issue in Bangladesh. Furthermore, it is a leading cause of death and disability in Bangladesh. A large proportion of patients present late, with advanced kidney failure and multiple complications. Management is hampered by the lack of health care services, especially in the rural areas. According sufficient prominence to CKD in education programs would help increase awareness.[3]. In general, patients with end-stage renal disease (ESRD) are not capable to sustain life without dialysis support. Hemodialysis is the transport process by which a solute passively diffuses down its concentration gradient from one fluid compartment (either blood or dialysate) into the other [4].

The main purpose of hemodialysis is exiting of the toxins from the body and preservation of its intracellular and extracellular composition in normal range the maximum amount as possible. The worldwide prevalence of long term dialysis continues to rise [5, 6] driven in part by strong trends towards the initiation of dialysis earlier in the natural history of CKD than was the practice previously [7]. The adequacy of hemodialysis refers to how well toxins and waste products are removed from the patient's blood and has a major impact on their well-being. Dialysis delivery should be adequate to improve adequacy of life and to prolong survival [8]. Studies have indicated an increase in morbidity and mortality among patients with inadequate dialysis [9]. It is a major outcome of chronic kidney disease (CKD), with a significant outcome on the quality of life (QOL) and health resource utilization. In addition to its costs, a large number of patients die from cardiovascular diseases before the initiation of renal replacement therapy [10]. Hemodialysis is one of the main modalities of renal replacement therapy [11].

Even though Hemodialysis treatment is successful in ameliorating many of the clinical manifestations of ESRD and in postponing otherwise imminent death, Hemodialysis patients still have higher mortality and hospitalization rates, as well as lower QOL, compared with the general population [12]. Hemodialysis, which was introduced in the 1970s, implies that dialysis should enable patients to have a normal QOL, as well as allow solid clinical tolerance with minimal problems during the dialysis and interdialysis periods [13]. Quantification of the dialysis dose is essential to the management of chronic Hemodialysis treatment because the adequacy of the dose has a profound effect on patient morbidity and mortality [14]. Dialysis delivery should be adequate to improve adequacy of life and to prolong survival [15]. Studies have indicated an increase in morbidity and mortality among patients with inadequate dialysis [16].

OBJECTIVES

General Objective:

The assessment of hemodialysis adequacy in patients with chronic kidney disease.

Specific Objectives:

To identify the clinical factors responsible for inadequate hemodialysis.

To Evaluate and identify treatment characteristics responsible for inadequate Hemodialysis

METHODS AND MATERIALS

This was a cross-sectional study conducted at Hemodialysis Unit, Department of Nephrology, Shere-e-Bangla Medical College and Hospital, Barishal. Study period was January, 2020 to December, 2020. Total Sample size was 55 cases. A questionnaire was prepared by the researcher considering the key variable like age, sex, presenting symptoms, clinical findings, associated medical conditions, investigations preoperative findings, outcome was verified by the guide. Data were collected by the researcher himself at hemodialysis unit, department of Nephrology, SBMCH. The patients were encouraged for voluntary participation. They were also assured about the secrecy of information's and records Data were collected over a period of twelve months. In the study we included all consenting population where adults ≥18 years of age undergoing chronic hemodialysis who were in a steady state at the time of data collection. All patients had a regular dialysate flow rate of 500 ml/min.

The calculation of URR and sp*Kt*/*V* was done using the formulas described above. Relevant data on sociodemographics and treatment characteristics were collected using structured questionnaires and patient's hospital records. The urea removal indexes help to calculate the adequacy of hemodialysis. The urea removal indexes include urea reduction ratio (URR), single-pool (sp*Kt*/*V*), equilibrated (e*Kt*/*V*), and the weekly standard index (std *Kt*/*V*). This study used URR and sp*Kt*/*V* to calculate hemodialysis adequacy. *Urea Reduction Ratio (URR) Index.* The URR can be assessed by measuring the blood urea nitrogen (BUN) level before and after dialysis. It is calculated as follows:

$$\text{URR} = \frac{(\text{Pre-dialysis BUN} - \text{Post-dialysis BUN})}{(\text{Pre-dialysis BUN}) \times 100\%}$$

Single-Pool Index (spKt/V). The sp*Kt*/*V* index is defined as the amount of serum that is cleared from urea via the distribution volume, in relation to the urea reduction ratio during hemodialysis. Parameter K is the dialyzer blood water urea clearance that is provided by the filter (measured as liters per hour), *t* is the duration of the hemodialysis session in hours, and *V* is the volume of urea distribution in combination with the body water in liters. The parameters sp*Kt*/*V* and URR are connected mathematically as follows:

$$\frac{\text{sp}Kt}{\text{V}} = -\ln(1 - \text{URR}),$$

Where, ln stands for natural logarithm. In addition, the sp*Kt*/*V* index counts the ultrafiltration and the urea production. However, none of the parameters surpass the other as a denouement criterion. Data were analyzed using SPSS 23, chi-square test and a logistic regression analysis. Relevant frequencies and appropriate tables were generated for different variables. Means and proportions were calculated for appropriate variables. All associated factors for inadequate dialysis were analyzed using HPSS 23, Chi-squared test. A logistic regression analysis was done to find out independent associating factors for inadequate hemodialysis. Statistical significance was set at *p* value <0.05.

RESULTS

A total of 55 participants were enrolled in the study. About two-thirds 65.5% were males and 34.5% were female (Table I). The mean age (±SD) was 51.7±1.2 years (Fig.1).

Table I: Sociodemographic characteristics of the study population. (n=55)

Characteristics	Frequency (*n =55)*	Percent (%)
Age (years)		
<40	11	22.0
≥40	44	80.0
Sex		
Male	36	65.50
Female	19	34.50
Marital status		
Married	49	89.09
Widowed	6	10.90
Education level		
No formal education	14	25.45
Primary	20	36.37
Secondary	15	27.27
College/University	6	10.91
Body mass index (kg/m^2) (Fig.2)		
Underweight (<19.5)	5	9.10
Normal (19.5–25.9)	31	56.36
Overweight (25–29.9)	15	27.27
Obese (>30)	4	7.27

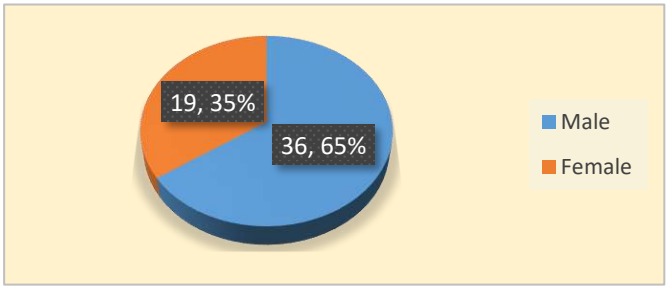

Fig 1: Age distribution

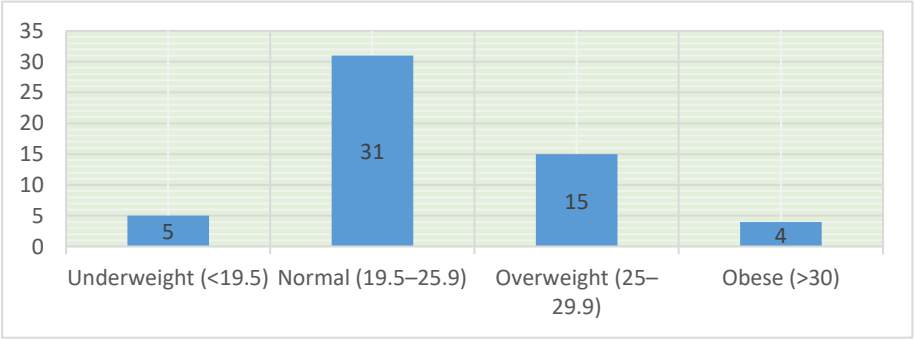

Table II: Demographic and clinical factors associated with inadequate hemodialysis (n=55)

Factors	URR		p value	Kt/V		p value
	Inadequate (%)	Adequate (%)		Inadequate (%)	Adequate (%	
Age (years)						
<40	7 (70.0)	3 (30.0)	0.656	6 (46.2)	7 (53.8)	0.434
≥40	29 (64.4)	16 (35.6)		25 (59.5)	17 (40.5)	
Sex						
Male	25 (69.4)	11 (30.6)	0.138	24 (66.6)	12 (33.4)	0.047
Female	11 (57.1)	8 (42.9)		9 (47.4)	10 (52.6)	
Marital status						
Married	21 (51.0)	20 (49.0)	0.741	28 (66.7)	14 (33.3)	0.956
Widowed	8 (57.14)	6 (42.86)		8 (61.5)	5 (38.5)	
Body mass index (kg/m^2)						
Underweight (<18.5)	4 (66.7)	2 (33.3)	0.931	4 (66.7)	2 (33.3)	0.962
Normal (18.5–24.9)	20 (66.7)	10 (33.3)		18 (58.1)	13 (41.9)	
Overweight (25–29.9)	10 (62.5)	6 (37.5)		8 (61.5)	7 (38.5)	
Obese (>30)	2 (62.5)	1 (37.5)		2 (62.5)	1 (37.5)	
Underlying disease						
Hypertension alone	21 (63.6)	12 (36.4)	0.380	18 (54.5)	15 (45.5)	0.831
Diabetes alone	4 (57.1)	3 (42.9)		4 (57.1)	3 (42.9)	
Hypertension and diabetes	7 (63.6)	4 (36.4)		6 (54.5)	5 (45.5)	
Others	3 (75.0)	1 (25.0)		3 (75.0)	1 (25.0)	

Proportion of Patients Receiving Inadequate Hemodialysis. The mean URR and *Kt/V* were 60.9 ± 12.0 % and 1.1 ± 0.3, respectively. The proportion of patients receiving adequate hemodialysis among patients undergoing chronic hemodialysis in SBMCH based on URR was 34.3% and based on *Kt/V* was 40.6%. By *Kt/V* criteria, males had significantly a higher prevalence of inadequate hemodialysis (66.6% versus 47.4%, *p value* 0.047) but not by URR criteria (69.4% versus 57.1%, *p value* 0.138) (Table II).

Table III: Treatment characteristics associated with inadequate hemodialysis. (n=55)

Factors	URR		p value	*Kt/V*		p value
	Inadequate (%)	Adequate (%)		Inadequate (%)	Adequate (%)	
Dialyzer surface area (m^2)						
<1.4	33 (68.8)	15 (31.2)	0.022	30 (85.7)	5 (14.3)	0.032
≥1.4	3 (42.9)	4 (57.1)		2 (10.0)	18 (90.0)	
Vascular access in the last month*						
Temporary	10 (71.4)	4 (28.6)	0.419	10 (66.7)	5 (33.3)	0.225
Permanent	26 (63.4)	15 (36.6)		23 (57.5)	17 (42.5)	
Months since dialysis initiation						
3–12	20 (62.5)	12 (37.5)	0.427	18 (56.3)	14 (43.7)	0.466
>12	16 (69.6)	7 (30.4)		14 (60.9)	9 (39.1)	
Number of dialysis sessions per week						

1	0	1 (100.0)	0.127	0	1 (100.0)	0.221
2	6 (66.7)	3 (33.3)		6 (66.7)	3 (33.3)	
3	30 (66.7)	15 (33.3)		27 (60.0)	18 (40.0)	
Dialysis sessions in a month						
2–11	12 (60.0)	8 (40.0)	0.300	12 (60.0)	8 (40.0)	0.900
>11	24 (68.6)	11 (31.4)		21 (60.0)	14 (40.0)	
Blood flow rate (ml/min)						
<250	5 (62.5)	3 (37.5)	0.940	5 (62.5)	3 (37.5)	0.560
≥250	31 (65.9)	16 (34.1)		27 (57.4)	20 (42.6)	
Ultrafiltration (liters)						
0–2	25 (65.7)	13 (34.3)	1.000	23 (60.5)	15 (39.5)	0.715
2–4	11 (64.7)	6 (35.3)		10 (58.8)	7 (41.2)	
Hemoglobin (g/dL)						
<10	17 (70.8)	7 (29.2)	0.201	17 (69.8)	7 (30.2)	0.028
≥10	19 (61.3)	12 (38.7)		16 (51.6)	15 (48.4)	

Patients using a dialyzer surface area of less than 1.4 m^2 had significantly more inadequate hemodialysis as compared to those with dialyzer surface area ≥1.4 m^2 (68.8% versus 42.9%, *p value* 0.022, by URR criteria (85.7% versus 10%, *p value* 0.032, by *Kt*/*V* criteria) (Table 3). By *Kt*/*V* criteria, patients who had hemoglobin of <10 g/ dl in the last month had significantly more inadequate hemodialysis as compared to those who had hemoglobin of ≥10 g/dl. This association was not seen when using URR criteria (70.8% versus 61.3%, *p value* 0.201, by URR criteria) (69.8 versus 51.6%, *p value* 0.028, by *Kt*/*V* criteria) (Table III).

Table IV: Logistic regression analysis for factors with inadequate hemodialysis.

Characteristic	Adjusted OR	95% CI	*p* value
By URR			
Sex—male	0.58	0.28–1.20	0.144
Hb < 10 g/dL[b]	0.67	0.33–1.38	0.278
DSA < 1.4 m^2[c] By *Kt*/*V*	1.58	0.54–4.60	0.402
Sex—male[a]	0.49	0.24–1.00	0.050
Hb < 10 g/dL[b]	0.49	0.24–1.00	0.050
DSA < 1.4 m^2[c]	1.23	0.41–3.72	0.708

The logistic regression analysis was done to find independent association of factors with inadequate hemodialysis in patients undergoing chronic hemodialysis in SBMCH. Factors that showed association in univariate analysis were included in the regression model. None of the factors showed independent association with inadequate hemodialysis in patients undergoing chronic hemodialysis by both URR and *Kt*/*V* (Table IV).
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DISCUSSION

This was a cross-sectional study looking at the prevalence of inadequate dialysis and its associated factors. In this study, the mean *Kt*/*V* was 1.1 and URR was 60.9%. Over the past 10 years, published data indicated that survival of dialysis patients is strongly associated with the delivered dialysis dose [17]. Improvements in survival rates at higher dialysis doses were reported for all major causes of mortality including coronary heart disease, other cardiac diseases such as stroke, and infection. This observation is compatible

with the hypothesis that low doses of dialysis may promote atherosclerosis, infection, malnutrition, and failure to thrive [18]. In this study, it was found that about one-third (34.3%) and 40.6% receive target URR (≥65%) and *Kt*/*V* (>1.2), respectively. Similar values for URR and *Kt*/*V* were found in studies done in Sari [19] and Rasht states and in Qom [20, 21]. A study in Ardabil showed that only 10% of patients received adequate hemodialysis [22].

This was in contrast to studies done in developed countries (DOPPS study and in the United States) where URR ranged from 60–90% and *Kt*/ *V* was more than 1.2 [23, 24]. This indicated that generally patients achieve less than the hemodialysis target therapy as per NKF-KDOQI 2006 recommendations [25]. These values were however better than the values reported in Iran (*Kt*/*V* 0.93, 1.17 and URR 53%) [26, 27]. This study revealed similar findings to those carried out in other developing countries such as Brazil, Nigeria, Nepal, and Pakistan [28–32] but they differed from those reported from developed countries such as the United States and from other five European countries as part of the DOPPS study where the mean delivered *Kt*/*V* varied from 1.28 to 1.50 [23]. In contrast, our results were in disagreement with those of Ghali and Malik [33]; there was no significant effect of increasing BFR on hemodialysis adequacy. They attributed their results to the effect of other factors affecting dialysis adequacy, such as malnutrition, anemia, short time of dialysis session, premature cessation of sessions of hemodialysis, infection, inadequate blood flow from vascular access, hypotension episodes, technical reasons, and the design of the study and the sample size. As regards the duration of hemodialysis sessions, analysis of the results of the present study revealed that clearance was strongly associated with increased duration of the dialysis process. Difference in clearance rates among the various duration periods was statistically significant ($P = 0.001$).

As regards the relationship between Kt/V and URR, the results of the present study revealed that all patients with spKt/V at least 1.2 had URR of at least 65% (statistically significant positive correlation between Kt/V and URR; $P < 0.001$). These results were in agreement with the study by Afshar *et al*. [34], who found a statistically strong correlation between URR and eKt/V ($P < 0.001$). In contrast, our results were in disagreement with the study by Oreo and Hamburger [35], who reported a poor correlation between URR and Kt/V in 942 patients when both values were measured simultaneously. As regards the BFR, analysis of the results of the present study revealed that increased BFRs were associated with increased rate of clearance. This is clear from the findings of Kt/V values of at least 1.2 (200–250 ml/min, 20%; 251–300 ml/min, 35.6%; more than 300 ml/min, 63.3%).

Difference in clearance rates among the various groups of BFRs was statistically significant ($P = 0.003$). These results were in agreement with the study by Kim *et al*. [36], Borzou *et al*. [37], Ward [38], and Port *et al*. [39]. These results were in agreement with the study by Stewart *et al*. [40], who showed that time still had a profound effect on dialysis adequacy, indicating the importance of ensuring that patients remain on dialysis for the full time prescribed. Even 5 min makes a big difference. For each 5 min that a treatment is shortened, the patient loses significant dialysis time when reviewed cumulatively over time [41]. As regards dialysis frequency, analysis of the results of the present study revealed improvement in clearance rates with increased dialysis frequency per week. Differences in clearance rates were statistically significant ($P = 0.012$). The findings in this respect were consistent with previous reports that linked improvements in clearance rates with frequency of dialysis [42]. At present, the Hemodialysis dose is quantified by the parameter Kt/V, which measures urea removal during treatment; a single-pool Kt/V of 1.2 is considered an adequate dose [43]. In contrast, the results

DBP, diastolic blood pressure; Hb, hemoglobin; nPCR, normalized protein catabolic rate; SBP, systolic blood pressure; URR, urea reduction ratio. of the present study were in disagreement with those reported from developed countries such as the USA, as, according to the 2007 annual report, over 90% of patients had a Kt/V greater than 1.2 [41]. As regards UF volume, analysis of the results of the present study revealed a clear trend of improvements in Kt/V values with increased UF rate (within limits, as decrease in clearance rate was noted in patients with UF volume >4 l).

Nevertheless, dissimilarities in the clearance rates among different groups were statistically insignificant (P = 0.056). Few studies have examined the direct association of UF rate on long-term outcomes in hemodialysis patients. The Netherlands Cooperative Study on the adequacy of dialysis recently reported the association between excessive ultrafiltration and mortality, independent of the delivered Kt/V urea [44]. As regards the active surface area of the dialyzer, analysis of the results of the present study revealed improvements in Kt/V values with increased dialyzer surface area. Difference in clearance rates were statistically significant (P = 0.005). Access recirculation (AR), analysis of the results of the present study revealed that low recirculation percentage would result in better dialysis adequacy. Differences in Kt/V values among these recirculation groups were statistically significant (P < 0.001).

In brief summary, the findings of the present study clearly showed that with increasing time and frequency of dialysis, BFRs, low recirculation percentages, reduction of intradialytic complaints, and well-functioning vascular access were associated with better dialysis adequacy. We recommend the following: individualizing the hemodialysis prescription based on monthly assessment of single-pool Kt/V would be beneficial and practical in providing safe and cost-effective hemodialysis treatment. To ensure that ESRD patients treated with chronic hemodialysis receive adequate treatment, the delivered dose of hemodialysis needs to be measured monthly. Hemodialysis centers should have a continuous quality improvement and patient review system in place that recognizes patients who are receiving suboptimal dialysis adequacy, identify the cause, and rectify it if possible, and assess whether targets are achieved in accordance with DOQI guidelines in an effort to achieve improved long-term outcomes in patients on chronic hemodialysis.

CONCLUSION

The study shown a major percentage of patients had inadequate Hemodialysis. Hemodialysis adequacy was influenced by several factors such as duration and frequency of the dialysis session, patients' complaints, and well-functioning vascular access. To provide the accurate hemodialysis dose count help improve hemodialysis adequacy.

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