A Study on the Impact of Adequacy of Maintenance Hemodialysis on Quality of Life in Chronic Kidney Disease Patients

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Abstract

Introduction: The study aimed to evaluate the impact of maintenance urea reduction ratio (URR) adequacy on the quality of life (QOL) in chronic kidney disease (CKD) patients and identify which components of the SF-36 health survey are the most affected by hemodialysis adequacy.
Method: The study involved 50 subjects on maintenance hemodialysis (MHD) for at least 3 months. The QOL was measured using a Short Form (SF)-36 Health Survey Questionnaire. HD adequacy was measured using spKt/V and urea reduction ratio (URR).
Results: Among the 50 patients, 35 (70%) had an AV fistula for vascular access, 9 (18%) had a permcath, equal number of patients 3 (3.9%) had an AV graft and HD catheter. The mean hemoglobin and albumin levels are 10.4 g/dL and 3.37 g/dL. Adequacy of dialysis, measured by Kt/V and URR, showed that 28% of patients had inadequate Kt/V (<1.2), and 34% had inadequate URR (< 65%). The association between Kt/V and URR was significant, indicating that patients with lower URR were more likely to have inadequate dialysis. Higher Kt/V values correlated with better energy fatigue and general health scores. Hemoglobin levels and Albumin levels were significantly associated with social functioning scores, suggesting the better outcome in patients with higher hemoglobin levels and higher albumin levels.
Conclusion: This study demonstrates that adequate HD, as measured by Kt/V and URR values, significantly impacts the QOL of CKD patients, particularly in terms of physical functioning, energy/fatigue, general health, and social functioning. Effective management of anemia and nutritional status further enhances these outcomes.

Keywords: India; Kidney Failure, Chronic/therapy; Quality of Life; Renal Dialysis

INTRODUCTION

End-stage renal disease (ESRD) is an irreversible condition requiring dialysis or kidney transplantation for patients to survive.[1] Globally, hemodialysis (HD) is the most common form of renal replacement therapy. Quantifying the dialysis dose is crucial in managing chronic HD management, as the adequacy of the dose significantly impacts patient morbidity and mortality.[2] Clinical signs, symptoms, and biochemical parameters alone are unreliable indicators of HD adequacy. The extent of urea removal measures the adequacy of dialysis. The "National Kidney Foundation Kidney Disease Outcomes Quality Initiative (NKF-K/DOQI)" considers three methods appropriate for measuring the delivered dose: urea kinetic modeling, Kt/V, and the urea reduction ratio (URR). Among these, Kt/V is the ideal method, while the URR is the simplest to execute and most widely used.[3] According to the 2015 KDOQI guidelines for HD patients, a target single pool Kt/V (spKt/V) of 1.4, with a minimum delivered spKt/V of 1.2, is recommended. In our study, we will use a single pool Kt/V of 1.2 or above and a URR of 65% or greater as adequacy measures.

The World Health Organization defines quality of life (QOL) as an individual's perception of their position in life within the context of the culture and value systems in which they live, and about their goals, expectations, standards, and concerns. QOL in ESRD patients is often overlooked, yet it is a crucial aspect of medical care.

Since patient role perception is more critical than clinical and biochemical parameters in assessing QOL, QOL questionnaires are frequently used. In our study, we will use the Medical Outcomes Study Short Form 36-Item Health Survey (SF-36) questionnaire to assess QOL scores. The

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SF-36 is a 36-item self-administered questionnaire that provides scores for eight domains of health-related quality of life (HRQOL): general health, physical functioning, role limitations due to physical problems, bodily pain, mental health, social functioning, role limitations due to emotional problems, and vitality. Scores range from 0 to 100, with higher scores indicating better QOL.[4,5]

Earlier research has primarily focused on the effects of erythropoietin, exercise, and the impact of various renal replacement therapy modalities.[6,7] Studies have indicated that initiating dialysis improves the QOL in ESRD patients, and numerous studies have shown that adequate dialysis enhances survival outcomes.[8,9] However, the relationship between dialysis adequacy indices and QOL remains inconsistent. This study aims to examine the relationship between QOL and HD adequacy, with the overall objective of providing crucial information for designing appropriate medical care for CKD patients, leading to better clinical outcomes. Additionally, it will investigate which components of the SF-36 are improved with adequate dialysis.

METHODS

This cross-sectional observational study was conducted at the Nephrology department, Narayana Medical College and Hospital Nellore for 18 months.

Inclusion criteria

- Age > 18 years
- On MHD for at least 3 months
- No h/o psychiatric disorder
- Clinically stable with no evidence of acute or chronic infections, inflammatory disorders, or malignancy.

Exclusion criteria

- Patients who refuse to be part of the study.
- Any clinical event requiring hospitalization in the last 1month
- Age <18 years.

Sample size

For a prospective study design based on a simple random sample, the sample size was calculated according to the formula.

$n = z\alpha^2 \times p\,(1-p)/m^2$

n = required sample size, zα = confidence level at 95% (standard value of 1.96),

p = estimated prevalence, m = margin of error at 11 % (standard value of 0.11)

For our prospective study design, we have 20% estimated prevalence at 95% confidence level (the standard value of z is 1.96) and we have 11 % margin of error.

The required sample size was 50.

Method

HD adequacy was measured using spKt/V and URR. The Kt/V is a dimensionless ratio representing the volume of plasma urea (Kt) divided by the urea distribution volume (V). K is the dialyzer blood water urea clearance (L/hr), t is dialysis length (hours, hr) and V is the distribution volume of urea (litres, L), which is close to total body water. Single pool Kt/V was calculated using the Daugirdas equation.

$Kt/V = \ln(R - 0.008Xt) + (4-3.5XR) \times UF/W$

Where UF is the ultrafiltration volume in liters, W is the post-dialysis weight in kg and R is the ratio of the post-dialysis to predialysis BUN, and t is the session length in hours. URR is a number expressed as a percentage that is used to quantify dialysis treatment adequacy. The URR was calculated as (predialysis urea- post-dialysis urea) divided by predialysis urea. A URR of 65 % or greater was taken as the minimum accepted value for adequate HD. Patients were divided into two groups, one with adequate dialysis (URR65% or above and spKt/V of or above) and the other with inadequate dialysis (URR less than 65% and spKt/V of 1.2 or less). Blood tests for urea were obtained through predialysis and post-dialysis every month for 3 months. Monthly averaged spKt/V and URR were then calculated.

The QOL was measured using a Short Form (SF) 36 health survey Questionnaire. Hindi as well as English versions of the questionnaire were used. QOL was assessed at the end of 3 months of observation. SF 36 consists of 36 items, which are assigned the following 8 domains: general health, physical functioning, role limitation due to physical problems, bodily pain, mental health, social functioning, role limitation due to emotional problems, and vitality. The first 4 domains constitute the physical component scale and the next 4 components constitute the mental component scale. In step 1, the raw score of each domain was then transferred to a standardized score in the 0 to 100 range. In step 2, Items in the same scale are averaged together to create the 8 scale scores. Higher scores indicate better QOL. Scores above 50 are considered adequate while scores lesser than 50 are inadequate. All patients were assisted in filling out the SF-36 questionnaire at the end of 3 months. The impact of HD adequacy on QOL scores was then assessed.

Data collection

A Proforma providing all historical and clinical details during the course of the study was used to record patient data. These included:

- The demographic profile of the patients
- Time on HD
- HD access
- Etiology of ESRD
- Predialysis urea
- Postdialysis urea
- UF volume
- Post-dialysis weight

- 3 consecutive month spKt/V and average sp Kt/V
- 3 consecutive months of URR and average URR
- Residual urine output
- CCI
- SF-36 Questionnaire at the end of 3 months

Laboratory parameters - hemoglobin, albumin, calcium, phosphorus

Statistical analysis

The data was collected and analyzed by using SPSS Version 21.0. Data was expressed as mean ±SD. The comparison between groups was performed by using Z- the test, paired t-test, and chi-square test. Fisher's test was used where appropriate. For the non-parametric test, Mann Whitney U test was applied. Correlation analysis was performed by using a correlation coefficient. A *p*-value of <0.05 was considered as significant.

RESULTS

Characteristics

A total of 50 subjects were involved in this study, with 27 males and 23 females. Most of the participants were aged between 45 and 65 years (n=22), while 18 were in the 65-85 years range, and 10 were aged between 25 and 45 years. The mean age of the patients was 51.23 ± 14.09 years. Among the 50 patients, 35 (70%) had an AV fistula for vascular access, 9 (18%) had a permcath, equal number of patients 3 (3.9%) had an AV graft and HD catheter. The CCI was assessed for all patients, showing high scores (≥ 6) in 22 patients, medium scores (4-5) in 13 patients, and low scores (≤ 3) in 15 patients. The average CCI score was 4.9 ± 2.2. The mean hemoglobin level was 10.4 g/dL with an SD of 1.69 g/dL, ranging from a minimum of 6.2 g/dL to a maximum of 13.49 g/dL, indicating variability in anemia status among the participants. The mean albumin level was 3.37 g/dL, with an SD of 0.28 g/dL, and it ranged from 2.59 g/dL to 4.08 g/dL, reflecting the participants' protein status. The mean calcium level was 8.37 mg/dL, with an SD of 0.77 mg/dL, and it varied between 6.83 mg/dL and 9.92 mg/dL. Mean phosphorus level was 5.61 mg/dL, with an SD of 2.39 mg/dL, and it spanned from 1.78 mg/dL to 11.94 mg/dL.

Distribution of Kt/V according to vascular access

Among the 14 patients with inadequate Kt/V values (< 1.2), none had an AV graft, 10 (71.43%) had an arteriovenous fistula (AVF), 1 (7.14%) used a HD catheter, and 3 (21.43%) had a Permcath. In comparison, among the 36 patients with adequate Kt/V values (≥ 1.2), 3 (8.33%) had an AV graft, 25 (69.44%) used an AVF, 2 (5.56%) had an HD catheter, and 6 (16.67%) had a Permcath (Table 1).

Table 1. Distribution of Kt/V according to vascular access, hemoglobin and albumin according to URR.

Access	Inadequate < 1.2 (n = 14)		Adequate ≥1.2 (n = 36)		*p*-value
	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)	
AV graft	0	0.00%	3	8.33%	0.7193
AVF	10	71.43%	25	69.44%	
HD Catheter	1	7.14%	2	5.56%	
Permcath	3	21.43%	6	16.67%	
Laboratory parameters	Inadequate < 65% (n = 17)		Adequate ≥ 65% (n = 33)		*p*-Value
Hemoglobin	9.98	1.73	11.21	1.52	0.07821
Albumin	3.32	0.31	3.4	0.26	0.3922

SF-36 scores

For physical functioning, the median score was 51, with scores ranging from 0 to 95 and an IQR of 4.25, indicating a moderate level of variability in physical health among the participants. General health had a median score of 33 with an IQR of 22.75, indicating variability in perceived health status (Table 2).

Table 2. SF-36 scores

QOL Indicators: Scores	Median	IQR	Minimum	Maximum
Physical functioning	51	4.25	0	95
Role limitations due to physical health	26	77.75	0	100
Role limitations due to emotional problems	98	20.76	48	100
Energy fatigue	45	33.76	9	75
Emotional wellbeing	68	16.75	24	96
Social functioning	37	38	0	100
Pain	53	33.75	0	100
General health	33	22.75	10	74

SF-36 scores amongst males and females

For physical functioning, females had a median score of 53 with an IQR of 48.5, while males had a median score of 49 with an IQR of 45. General health scores had a median of 40 with an IQR of 21 for females and 32 with an IQR of 21 for males (Table 3).

Table 3. SF-36 scores amongst males and females

QOL Indicators: Scores	Female		Male		*p*-Value
	Median	IQR	Median	IQR	
Physical functioning	53	48.5	49	45	0.5521
Role limitations due to physical health	16	65.5	59	84.5	0.07989
Role limitations due to emotional problem	100	15	92	24.5	0.2605
Energy fatigue	34	37.5	47	33.5	0.1691
Emotional wellbeing	69	16.5	67	37.5	0.4219
Social functioning	30	30.5	43	42	0.0519
Pain	48	34.5	59	27.5	0.4445
General health	40	21	32	21	0.2918

SF-36 scores and URR

General health had a median score of 25 with an IQR of 18 for those with URR < 65%, compared to 39 with an IQR of 21 for the URR ≥ 65% group. The *p*-value of 0.0498 indicated better perceived general health with a higher URR (Table 4).

Table 4. SF-36 scores in the adequate HD group (URR > 65 %) and inadequate group (URR<65%)

QOL Indicators: Scores	URR < 65%		URR ≥65%		*p*-Value
	Median	IQR	Median	IQR	
Physical functioning	41	51	56	43	0.9671
Role limitations due to physical health	33	76	67	74	0.2451
Role limitations due to emotional problems	96	22	99	17	0.7221
Energy fatigue	40	35	47	35	0.0478
Emotional wellbeing	67	42	69	16	0.5619
Social functioning	33	56	44	32	0.1679
Pain	58	28	53	40	0.3693
General health	25	18	39	21	0.0498

SF-36 and sp Kt/V

For physical functioning, patients with Kt/V < 1.2 had a median score of 40 and an IQR of 28.5, while those with Kt/V ≥1.2 had a median score of 54.5 with an IQR of 47.75. Significant differences were observed in energy fatigue and general health between the Kt/V groups, while other QOL indicators did not show statistically significant variations (Table 5).

Table 5. SF-36 scores in patients with Kt/V >1.2 and with Kt/V ≥1.2

QOL Indicators: Scores	Kt/V < 1.2		Kt/V ≥1.2		*p*-Value
	Median	IQR	Median	IQR	
Physical functioning	40	28.5	54.5	47.75	0.8637
Role limitations due to physical health	29.5	46.25	65.5	74.5	0.1299
Role limitations due to emotional problems	98	19.75	98	20.25	0.8546
Energy fatigue	36	28.25	53	35.75	0.004
Emotional wellbeing	64	25.25	68	14.5	0.9181
Social functioning	34.5	57.25	43.5	32.75	0.1872
Pain	52	31	62	35.25	0.2880
General health	33	22	34	22.25	0.018

Hemoglobin and SF-36 scores

For physical functioning, patients with hemoglobin < 10 g/dL had a median score of 39.5 with an IQR of 38, while those with hemoglobin ≥ 10 g/dL had a median score of 58.5 with an IQR of 48.75. The analysis found a significant difference only in social functioning, with higher hemoglobin levels associated with better social functioning scores (Table 6).

Table 6. Association of hemoglobin and SF-36 scores

QOL Indicators: Scores	Hemoglobin < 10	Hemoglobin ≥10	*p*-Value		
	Median	IQR	Median	IQR	
Physical functioning	39.5	38	58.5	48.75	0.6745
Role limitations due to physical health	41	82.5	53	74.25	0.4093
Role limitations due to emotional problems	100	14.5	91.5	26.5	0.1532
Energy fatigue	37.5	49.5	55	29.5	0.1951
Emotional wellbeing	69.5	12.5	64.5	27.75	0.3414
Social functioning	28	44.25	37	28.5	0.046
Pain	50	35.25	55.5	32.25	0.6635
General health	33	15	35.5	32.25	0.4911

Albumin and SF-36 scores

For physical functioning, the median score for those with albumin < 3.5 g/dL was 47.5 with an IQR of 45.25, compared to a median score of 52.5 with an IQR of 42.25 for those with albumin ≥ 3.5 g/dL (Table 7). Significant differences were observed in social functioning and borderline significance in pain, with higher albumin levels associated with better social functioning and potentially improved pain scores.

Table 7. Albumin levels and SF-36 domains

QOL Indicators: Scores	Albumin < 3.5		Albumin ≥3.5		*p*-Value
	Median	IQR	Median	IQR	
Physical functioning	47.5	45.25	52.5	42.25	0.9927
Role limitations due to physical health	56.5	76.25	65	76.25	0.1211
Role limitations due to emotional problems	92.5	21.5	100	13.5	0.2968
Energy fatigue	55	33.25	42	37.25	0.6992
Emotional wellbeing	63	16.75	70.5	19.75	0.7968
Social functioning	35	44.75	41.5	23.75	0.0071
Pain	53	32.5	54.5	28	0.050
General health	33	23	36	20	0.6296

DISCUSSION

In this study, arteriovenous fistulas (AVFs) were the most common vascular access, with 70.00% of patients dialyzed using AVF. This aligns with KDOQI guidelines that recommend AVF as the preferred access method. However, no statistically substantial association was found between Kt/V and vascular access (*p*=0.7193), possibly due to the small number of patients with non-AVF access. In our study, the CCI revealed high comorbidity burdens among the participants, with a mean score of 4.9 ± 2.2, the majority of subjects had high CCI (44%). In a previous report, the mean CCI was reported to be 4.1.[10]

The mean hemoglobin level was 10.4 g/dL, with a significant number of patients experiencing anemia, a common complication in CKD due to reduced erythropoietin production. 28% of patients had inadequate Kt/V values (< 1.2), and 34% had inadequate URR values (< 65%), indicating suboptimal dialysis in a significant subset of the cohort. This inadequate dialysis can contribute to the worsening of symptoms and a decline in QOL.

In our study, 72% of the population received adequate dialysis (sp Kt/V ≥1.2). In contrast, the 2007 annual report from the USA indicated that over 90% of patients had a Kt/V >1.2.[11] Studies from other developing countries, such as Brazil, Nigeria, and Nepal, have shown that 35%-45% of patients had a Kt/V >1.2.[12] Our findings fall midway between those of developing and developed countries.

Regarding the association between Kt/V and URR, our results showed that all patients with a spKt/V greater than 1.2 also had a URR greater than 65%. This correlation was found to be statistically significant, with a *p*-value <0.0001. These findings are consistent with those of Afshar *et al,* who also found a strong relationship between URR and Kt/V.[13]

In our study, the mean Kt/V and URR did not differ across gender or age groups. However, multiple studies attribute higher Kt/V in females to lower weight, lower BMI, and smaller volume of distribution.[14,15]

The mean hemoglobin in our study was 10.4 ± 1.69. Although the mean hemoglobin in the adequate HD group (Kt/V ≥ 1.2) was higher than in the inadequate group, the difference was not statistically significant. The mean albumin level was 3.37 ± 0.28. There was no statistically significant correlation between serum albumin and Kt/V, which contrasts with Azar *et al* study which found a strong positive correlation between Kt/V and albumin. The lack of correlation in our study may be because albumin is a negative acute phase reactant that can fluctuate under various conditions.

Patients on HD often experience significantly impaired QOL due to the substantial psychosocial burden it imposes.[16] These patients frequently face high rates of depression, anxiety, and a sense of impending demise. The many restrictions ESRD patients endure, such as dietary limitations, fixed treatment schedules, increased dependency on family, and various physical and psychological constraints, often lead to social withdrawal and strained personal relationships. Our study found that ESRD patients have lower QOL scores, consistent with numerous previous studies.[17,18] The SF-36 tool is a valid and reliable instrument for assessing QOL in CKD patients.[19,20]

In a study by Manns *et al*, the lowest score of 24 was found in the domain of role limitations due to physical health, which was similar to our median score of 26 in this domain.[21] Median scores of 41.6, 42, and 45 in the domains of general health, energy/fatigue, and physical functioning, respectively, were reported, while our study found scores of 33, 45, and 51 in these domains. The only difference was observed in the domain of social functioning, which was affected only in our study.

Similar results were found by Spiegel *et al* in a systematic review, where the most profound effects were on physical functioning and vitality, with the least pronounced effects on mental health.[9] Likewise, the HEMO study, which measured HRQOL as a secondary outcome, found that at baseline, the SF-36 PCS score was lower than in healthy populations, while the mental component score was nearly normal. Over a follow-up period of three years, physical health scores continued to decline, but mental health remained stable.

In our study, emotional well-being and role limitations due to emotional well-being and pain were not significantly affected. Patients did not exhibit high levels of depression or anxiety, which may be attributed to strong cultural family support. In contrast, a study by Weisbord *et al* reported that up to 50% of ESRD patients experienced symptoms like fear, worry, sadness, strain, and depression.[22] The PCS score in our study was 55, which differs from the lower score of 48 found by Kalantar-Zadeh *et al*, possibly due to their older study group (mean age 54.5 yr).[8] The MCS score in our study was 46, which is similar to the score of 48.8 reported by Kutner *et al*.[7]

In our study, we examined the impact of HD adequacy on SF-36 QOL scores and observed a positive association between dialysis dose (Kt/V and URR) and scores in the general health and energy/fatigue domains ($p < 0.05$). Our results align with Manns *et al*, who reported that better Kt/V improved six out of eight SF-36 domains. Similarly, Simic-Ogrizovic *et al*, observed that improved treatment, including better dialysis quality and anemia management, significantly increased scores in energy/fatigue, physical functioning, and role limitations due to physical activity.[23]

A study found no significant correlation between dialysis adequacy and SF-36 domains, and a larger Chinese study noted no meaningful QOL differences between patients dialyzing twice versus three times weekly.[24,25]

Our study also observed no substantial variance in QOL scores between males and females, consistent with Acaray and Pinar's findings, though Suet-Ching reported worse QOL for female patients.[26] Nutritional factors such as hemoglobin and albumin are crucial as they can be modified to improve patient outcomes. In our study, a significant association was found only in the social functioning domain of SF-36 with hemoglobin, likely due to minimal variability in hemoglobin levels among patients, possibly because of routine erythropoietin use.[27]

Serum albumin, a key marker of poor outcomes in HD patients, was associated with lower SF-36 scores in our study, particularly in the social functioning and pain domains. Kurella *et al* documented a significant correlation between albumin and disease-targeted HRQOL using the KDQOL cognitive function subscale, reinforcing the link between low albumin and poor QOL.[28]

The study's strength lies in its focus on the impact of dialysis adequacy on the QOL for dialysis patients, a relatively underexplored topic. The QOL was objectively measured using the standardized SF-36 tool.

However, the sample size was small and may not be representative of the broader CKD population. The cross-sectional design limits the ability to infer causality between dialysis adequacy and QOL. The study did not account for all potential confounding factors, such as differences in medication, dialysis modalities, and adherence to dietary restrictions, which could impact QOL. Future research should include larger, more diverse populations and consider longitudinal designs to better understand the causal relationships between dialysis adequacy and QOL improvements.

CONCLUSION

Our study demonstrates that adequate HD, as measured by Kt/V and URR values, significantly impacts the QOL of CKD patients, particularly in terms of physical functioning, energy/fatigue, general health, and social functioning. Effective management of anemia and nutritional status further enhances these outcomes. These findings highlight the need for continuous monitoring and optimization of dialysis parameters to improve the overall well-being of CKD patients. Upcoming research should discover targeted interventions to address the specific QOL dimensions most affected by dialysis adequacy.

Ethical Disclosures

Approval: This study was approved by the Institutional ethics committee, Narayana medical college and hospital, Nellore, Andhrapradesh, India (approval code IEC/NMC/9.01.2023_1 dated 19 January 2023).

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Protection of Human and Animal Subjects: The authors declare that the procedures followed were in accordance with the regulations of the relevant clinical research ethics committee and those of the Code of Ethics of the World Medical Association (Declaration of Helsinki as revised in 2024).

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Contributorship Statement

AS: Approach, formal analysis, research, materials, data gathering, Analysis and interpretation of results

RS: Research, materials, data collection, and creation of the first draft.

PK: Ideation, writing, editing, data curation, formal analysis, research, resources, technique and review.

AS, RS, PK: Critical reviewing of the content of the article.

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