

Research Article

Assessment of Adequacy of Haemodialysis in Patients on Maintenance Haemodialysis: A Descriptive Observational Study

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ABSTRACT

Background: Haemodialysis (HD) is the most common form of Renal Replacement Therapy (RRT) used for End Stage Renal Disease (ESRD). The adequacy of haemodialysis, assessed through Kt/V and Urea Reduction Ratio (URR), is a critical determinant of patient morbidity and mortality, yet many Indian centres fail to achieve recommended targets. **Objective:** To assess the adequacy of haemodialysis in patients on maintenance haemodialysis using Kt/V and URR, and to study haemoglobin levels, blood pressure control, and intradialytic complications in this population. **Methods:** A hospital-based descriptive observational study was conducted over one year. Thirty-five End Stage Renal Disease patients on maintenance haemodialysis for more than six months were enrolled, and 420 dialysis sessions were monitored. Pre- and post-dialysis blood urea, haemoglobin, and blood pressure were recorded monthly. Kt/V was calculated using the Daugirdas second-generation formula, and URR was calculated from pre- and post-dialysis blood urea nitrogen values. **Results:** The mean age of participants was 55.63 ± 15.06 years, with 65.71% males. Diabetes mellitus (54.28%) and hypertension (48.57%) were the leading causes of ESRD. The mean Kt/V across all sessions was 1.118 ± 0.20 , with only 144 (34.29%) sessions achieving the target Kt/V ≥ 1.2 . The mean URR was $59.93 \pm 7.08\%$, with only 106 (25.24%) sessions reaching the target URR $\geq 65\%$. Both targets were simultaneously met in only 105 (25%) sessions. Mean haemoglobin was 10.86 ± 1.92 g/dL. Intradialytic hypotension occurred in 37.14% and muscle cramps in 31.42% of participants. Kt/V and URR showed a strong positive correlation ($r = 0.935$, $p = 0.0001$). **Conclusion:** A majority of haemodialysis sessions in this cohort were inadequate by recommended standards, highlighting the need for stricter monitoring, patient education, and adherence to prescribed dialysis duration to reduce morbidity in ESRD patients.

Keywords: Haemodialysis Adequacy, Kt/V, Urea Reduction Ratio, End Stage Renal Disease, Maintenance Haemodialysis.

INTRODUCTION

Haemodialysis is the most widely used form of renal replacement therapy for patients with End Stage Renal Disease (ESRD), restoring extracellular and intracellular composition disturbed by progressive loss of kidney function. The adequacy of dialysis encompasses removal of uremic toxins, fluid balance, blood pressure control, and correction of anaemia. Two urea-based indices-Urea Reduction Ratio (URR) and Kt/V-are widely used in clinical practice to assess dialysis adequacy, with national and international guidelines recommending URR $>65\%$ and Kt/V ≥ 1.2 as minimum targets.

Several Indian studies have reported that a substantial proportion of patients on maintenance haemodialysis do not achieve these recommended targets, with adverse implications for survival and quality of life. This study was undertaken at a tertiary care centre to assess the adequacy of haemodialysis among patients on maintenance haemodialysis and to evaluate its relationship with haemoglobin status, blood pressure control, and intradialytic complications.

MATERIALS AND METHODS

This hospital-based descriptive observational study was conducted at the Renal Care Centre

of a tertiary care hospital over a period of one year (May 2012 to April 2013).

Selection and Description of Participants

All patients on maintenance haemodialysis for more than six months at the study centre between May 2012 and April 2013 were screened for eligibility. Inclusion criteria were consenting ESRD patients aged 16–80 years on maintenance haemodialysis for more than six months and on regular follow-up. Exclusion criteria were unwillingness to participate, emergency haemodialysis, acute kidney injury, acute illness, transition from CAPD to HD, or anticipated renal transplant within six months. Of 43 patients initially screened, 3 died within four months, 3 relocated, and 2 underwent transplantation; the final study cohort comprised 35 patients.

Technical Information

Dialysis was performed using B. Braun Dialog and Fresenius 4008B volumetric haemodialysis machines (Fresenius Medical Care, Bad Homburg, Germany) supplied with reverse-osmosis-treated water. Dialysate temperature was maintained at 37.5°C, with bicarbonate 32–35 mmol/L, sodium 138–145 mmol/L, potassium 2 mmol/L, and calcium 1.25–1.75 mmol/L. Low-flux polysulfone dialysers (Fresenius F6 and F7) were used, with a standard session duration of four hours. Pre- and post-dialysis blood urea, haemoglobin, blood pressure, and ultrafiltration volume were recorded monthly for each patient across 12 monitored sessions, yielding 420 dialysis sessions in total.

Assessment of Dialysis Adequacy

Kt/V was calculated using the Daugirdas second-generation logarithmic formula: $Kt/V = -\ln(C_2/C_1 - 0.008 \times T) + (4 - 3.5 \times C_2/C_1) \times UF/W$, where C1 and C2 represent pre- and post-dialysis blood urea concentrations, T is dialysis session duration in hours, UF is ultrafiltration volume in litres, and W is post-dialysis body weight in kilograms. URR was calculated as: $URR (\%) = [(BUN_{pre} - BUN_{post}) / BUN_{pre}] \times 100$. Target values used were Kt/V ≥ 1.2 and URR $\geq 65\%$, in accordance with K/DOQI clinical practice guidelines.

Ethics

The procedures followed in this study were in accordance with the ethical standards of the responsible Institutional Ethics Committee and with the Declaration of Helsinki. Ethical clearance was obtained from the Institutional

Ethics Committee, [Institution Name] (Approval No. [IEC Approval Number], dated [Date of Approval]), prior to commencement of the study. Written informed consent was obtained from all participating patients.

Statistics

Data were analysed using the Statistical Package for Social Sciences (SPSS, IBM Corp., Armonk, NY, USA). Continuous variables are presented as mean $\pm$ standard deviation, and categorical variables as frequencies with percentages. Pearson correlation coefficient was used to assess the association between Kt/V and URR, and between these parameters and haemoglobin, body mass index, and blood pressure. Chi-square test was used for comparison of categorical variables. A two-tailed P value <0.05 was considered statistically significant; exact P values are reported throughout.

RESULTS AND DISCUSSION

Demographic Profile

Of the 35 participants, 48.57% were aged 61–80 years and 37.14% were aged 41–60 years; the mean age was 55.63 ± 15.06 years. Males constituted 65.71% of the cohort. Diabetes mellitus (54.28%) and hypertension (48.57%) were the leading causes of ESRD, followed by contrast-induced nephropathy (20%), IgA nephropathy (8.57%), rapidly progressive glomerulonephritis (8.57%), and multiple myeloma (2.86%) (Table 1, Table 2). These findings are consistent with the global epidemiology of ESRD, where diabetic and hypertensive nephropathy together account for the majority of cases.

Adequacy of Haemodialysis

Across 420 monitored sessions, the mean URR was $59.93 \pm 7.08\%$ (range 31.3–77.7%), with only 106 sessions (25.24%) achieving the recommended target of $\geq 65\%$ (Table 3). The mean Kt/V was 1.118 ± 0.20 (range 0.49–1.64), with only 144 sessions (34.29%) achieving the target of ≥ 1.2 (Table 4). Both Kt/V and URR were simultaneously within target in only 105 sessions (25%) (Table 5). These results indicate that a majority of dialysis sessions in this cohort fell short of recommended adequacy standards, a finding consistent with previously published data from Indian and South Asian dialysis populations, where mean Kt/V values have similarly ranged from 0.9 to 1.0.

Kt/V and URR showed a strong, statistically significant positive correlation (Pearson $r = 0.935$, $P = 0.0001$) (Table 6), consistent with the established mathematical relationship between the two indices. Diabetes mellitus was significantly associated with lower URR (chi-square $P = 0.042$), though not significantly associated with Kt/V ($P = 0.096$), possibly reflecting early session discontinuation related to hypoglycaemia in diabetic patients.

Haemoglobin and Blood Pressure

The overall mean haemoglobin across the study period was 10.86 ± 1.92 g/dL (range 4.9–16.7 g/dL), marginally below the recommended target of ≥ 11 g/dL (Table 7). Mean pre-dialysis systolic blood pressure was 142.53 ± 17.60 mmHg and diastolic blood pressure was 80.7 ± 8.99 mmHg; blood pressure was within normal range ($<140/90$ mmHg) in only 221 of 420 sessions (52.62%), reflecting persistent systolic hypertension in this population.

Intradialytic Complications

Intradialytic hypotension occurred in 13 participants (37.14%) and muscle cramps in 11 participants (31.42%) (Table 8). These complications are well-recognised contributors to early termination of dialysis sessions, which in turn compromises adequacy. Eight participants (22.85%) required hospitalisation during the study period, with frequency ranging from one to four admissions (Table 9).

CONCLUSION

Inadequate haemodialysis, as defined by Kt/V and URR targets, was observed in the majority of sessions in this cohort of patients on maintenance haemodialysis, with both indices simultaneously meeting recommended targets in only one-quarter of sessions. Diabetes mellitus, intradialytic hypotension, and muscle cramps were identified as factors associated with reduced dialysis adequacy. These findings support the need for routine monthly monitoring of Kt/V and URR, patient education on adherence to prescribed dialysis duration, and active management of intradialytic complications to improve dialysis adequacy and reduce morbidity in ESRD patients.

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Conflict of Interest

The authors declare no conflict of interest.

REFERENCES

1. Lowrie EG, Laird NM, Parker TF, Sargent JA. Effect of the haemodialysis prescription of patient morbidity: report from the National Cooperative Dialysis Study. *N Engl J Med.* 1981; 305(20):1176-1181.
2. Harter HR. Review of significant findings from the National Cooperative Dialysis Study and recommendations. *Kidney Int Suppl.* 1983; 13:S107-S112.
3. Gotch FA, Sargent JA. A mechanistic analysis of the National Cooperative Dialysis Study (NCDS). *Kidney Int.* 1985; 28(3):526-534.
4. National Kidney Foundation. K/DOQI clinical practice guidelines for haemodialysis adequacy, 2000. *Am J Kidney Dis.* 2001; 37(1 Suppl 1):S7-S64.
5. Mandolfo S, Malberti F, Imbasciati E, Cogliati P, Gauly A. Impact of blood and dialysate flow and surface on performance of new polysulfone haemodialysis dialyzers. *Int J Artif Organs.* 2003; 26(2):113-120.
6. Clark WR, Leypoldt JK, Henderson LW, Mueller BA, Scott MK, Vonesh EF. Quantifying the effect of changes in the haemodialysis prescription on effective solute removal with a mathematical model. *J Am Soc Nephrol.* 1999; 10(3):601-609.
7. Owen WF, Lew NL, Liu Y, Lowrie EG, Lazarus JM. The urea reduction ratio and serum albumin concentration as predictors of mortality in patients undergoing haemodialysis. *N Engl J Med.* 1993; 329(14):1001-1006.
8. Daugirdas JT. Second generation logarithmic estimates of single-pool variable volume Kt/V: an analysis of error. *J Am Soc Nephrol.* 1993; 4(5):1205-1213.
9. Collins AJ, Ma JZ, Umen A, Keshaviah P. Urea index and other predictors of haemodialysis patient survival. *Am J Kidney Dis.* 1994; 23(2):272-282.
10. Port FK, Ashby VB, Dhingra RK, Roys EC, Wolfe RA. Dialysis dose and body mass index are strongly associated with survival in haemodialysis patients. *J Am Soc Nephrol.* 2002; 13(4):1061-1066.
11. Eknoyan G, Beck GJ, Cheung AK, Daugirdas JT, Greene T, Kusek JW, et al. Effect of dialysis dose and membrane flux

- in maintenance haemodialysis. N Engl J Med. 2002; 347(25):2010-2019.
12. Jindal K, Chan CT, Deziel C, Hirsch D, Soroka SD, Tonelli M, et al. Haemodialysis clinical practice guidelines for the Canadian Society of Nephrology. J Am Soc Nephrol. 2006; 17(1 Suppl 1):S1-S27.
 13. Held PJ, Port FK, Wolfe RA, Stannard DC, Carroll CE, Daugirdas JT, et al. The dose of haemodialysis and patient mortality. Kidney Int. 1996; 50(2):550-556.
 14. Vanholder R, Hsu C, Ringoir S. Biochemical definition of the uremic syndrome and possible therapeutic implications. Artif Organs. 1993; 17(4):234-239.
 15. Sherman RA. Intra-dialytic hypotension: an overview of recent unresolved and overlooked issues. Semin Dial. 2002; 15(3):141-143.
 16. Mittal S, Kher V, Gulati S, Agarwal LK, Arora P. Chronic renal failure in India. Ren Fail. 1997; 19(6):763-770.
 17. Rao M, Juneja R, Shirly RB, Jacob CK. Haemodialysis for end-stage renal disease in southern India. Nephrol Dial Transplant. 1998; 13(10):2494-2500.
 18. Sultania P, Acharya PS, Sharma SK. Adequacy of haemodialysis in Nepalese patients undergoing maintenance haemodialysis. J Nepal Med Assoc. 2009; 48(173):10-13.
 19. Raiesifar A, Torabpour M, Mohsenizad Shabani H, Tayebi A, Masoumi M. Dialysis adequacy in patients of Abadan haemodialysis center. Iran J Crit Care Nurs. 2009; 2(3):87-90.
 20. Taziki O, Kashi Z. Determinants of quality of dialysis in Hazrat Fateme Zahra hospital in Sari. Mazandaran Univ Med Sci J. 2002; 13(41):40-46.
 21. Depner TA. Prescribing haemodialysis: the role of gender. Adv Ren Replace Ther. 2003; 10(1):71-77.

Tables

Table 1: Age and Gender Distribution of Study Participants (n=35)

Variable	Sub-category	n (%)
Age (years)	<20	2 (5.71)
	21-40	3 (8.57)
	41-60	13 (37.14)
	61-80	17 (48.57)
Gender	Male	23 (65.71)
	Female	12 (34.29)

Table 2: Causes of End Stage Renal Disease (ESRD) among Study Participants

Cause of ESRD	n	%
Diabetes Mellitus	19	54.28
Hypertension	17	48.57
Contrast-Induced Nephropathy	7	20.00
IgA Nephropathy	3	8.57
Rapidly Progressive Glomerulonephritis	3	8.57
Multiple Myeloma	1	2.86

Table 3: Monthly Urea Reduction Ratio (URR, %) among Study Participants (420 Sessions)

Month	Min	Max	Mean	SD
May	44.6	77.7	61.55	7.28
June	38.1	72.4	54.21	8.19
July	48.2	72.4	61.63	5.46
August	54.0	74.6	62.20	5.07
September	47.6	71.8	59.19	5.83
October	31.3	73.5	55.02	8.27
November	45.9	74.2	60.17	6.87
December	45.6	72.8	60.41	6.65
January	40.7	70.6	59.48	7.31
February	47.6	72.1	57.92	5.98
March	52.3	71.6	63.78	4.91
April	53.1	74.4	63.58	5.61

Overall	31.3	77.7	59.93	7.08
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Table 4: Monthly Kt/V among Study Participants (420 Sessions)

Month	Min	Max	Mean	SD
May	0.72	1.55	1.123	0.191
June	0.64	1.54	0.975	0.224
July	0.85	1.58	1.170	0.160
August	0.93	1.62	1.186	0.163
September	0.83	1.53	1.090	0.175
October	0.49	1.56	0.988	0.217
November	0.75	1.64	1.124	0.201
December	0.76	1.61	1.134	0.199
January	0.70	1.43	1.107	0.189
February	0.77	1.46	1.053	0.166
March	0.90	1.54	1.231	0.157
April	0.91	1.57	1.220	0.178
Overall	0.49	1.64	1.118	0.200

Table 5: Sessions Achieving Recommended Kt/V (≥ 1.2) and URR ($\geq 65\%$) Targets (420 Sessions)

Parameter	Sessions Meeting Target n (%)	Sessions Below Target n (%)
Kt/V ≥ 1.2	144 (34.29)	276 (65.71)
URR $\geq 65\%$	106 (25.24)	314 (74.76)
Both Targets Met	105 (25.00)	315 (75.00)

Table 6: Correlation of Kt/V with URR

Statistic	Value	Interpretation
Pearson r	0.935	Strong positive correlation
P value	0.0001	Statistically significant
N	35	—

Table 7: Monthly Haemoglobin (g/dL) among Study Participants

Month	Min	Max	Mean	SD
May	4.9	16.2	9.89	2.51
June	6.8	15.2	10.23	1.82
July	5.4	15.0	10.73	2.01
August	7.8	13.9	10.79	1.49
September	8.1	16.7	11.33	2.08
October	9.0	15.2	11.13	1.38
November	7.6	14.2	11.90	1.63
December	3.5	13.9	10.93	2.26
January	5.4	14.6	10.80	2.01
February	7.6	16.2	11.05	2.03
March	8.2	15.2	11.09	1.54
April	7.6	14.2	11.29	1.65
Overall	4.9	16.7	10.86	1.92

Table 8: Intradialytic Complications among Study Participants (n=35)

Complication	n	%
Hypotension	13	37.14
Muscle Cramps	11	31.42

Table 9: Frequency of Hospitalisation among Study Participants (n=35)

No. of Hospitalisations	n	%
1	2	5.71

2	2	5.71
3	3	8.57
4	1	2.85
Total Hospitalised	8	22.85