Original Article

Adequacy of Haemodialysis in Two Centres in Southwestern Nigeria: Determinants and Clinical Correlates

Uduagbamen PK[1,2], Uka AT[1], Ogunmola MI[1], Attah C[1], Alao OJ[1], Falana TE[1]

[1]Division of Nephrology and Hypertension, Department of Internal Medicine, Ben Carson (Snr) School of Medicine, Babcock University Teaching Hospital, Babcock University, Ilishan-Remo, [2]Nephrology Unit, Department of Internal Medicine, Federal Medical Centre, Abeokuta, Ogun State, Nigeria

ABSTRACT

Background: Dialysis remains the most common modality of renal replacement therapy for managing end-stage kidney disease. Optimisation of various measures is needed for its efficient delivery. Inadequate dialysis is common in many low-income nations, and there could be inter-centre differences in the delivered dose.
Aim: We assessed the dialysis adequacy and factors associated with inter-centre variation.
Materials and Methods: This was a two-centre comparative study. Participants' sociodemographic and examination findings were documented and dialysis was prescribed. Pre- and post-dialysis blood for electrolytes, urea and creatinine were taken, and urea reduction ratio and fractional urea clearance as a function of its distribution volume (Kt/V) were calculated.
Results: Two hundred and thirty-two participants had 1248 dialysis sessions. Participants' mean age was 49.9 ± 4.6 years. More males participated in the study, and males also received more sessions per participant. A greater proportion of the participants had tertiary education and had hypertensive nephropathy as the cause of kidney disease. The internal jugular access was used for dialysis in majority (60.6%) of the dialysis sessions. Dialysis dose (DD) was adequate in only 115 (9.2%) sessions. The mean DD was 1.02 ± 0.4; in the two centres, it was 0.86 ± 0.2 and 1.11 ± 0.5.
Conclusion: DD is low in many low-income nations including Nigeria. The DD was directly related to the blood flow rate, dialysis duration and frequency of erythropoietin use. In addition to other factors, inability to afford prescribed dialysis regimen is a major contributor to the low DD in low-income settings.

Key words: Blood pressure, dialysis, oxygen saturation, urea reduction ratio

INTRODUCTION

Dialysis is the most common of the renal replacement modalities for the treatment of end-stage kidney disease (ESKD) worldwide. Its effective delivery removes the symptoms of uraemia, improves quality of life (QOL) and prolongs life.[1] However, its delivery could be associated with setbacks which tend to be more in low-income settings, and this has impacted negatively on patients' QOL and increased the morbidity and mortality rates.[2] The dialysis dose (DD) is the amount delivered at the end of dialysis, and it is said to be adequate when it gives the full benefit of the dialysis therapy by removing wastes and toxins, correcting acidosis, preventing uraemia and thereby giving acceptable levels of morbidity and mortality.[3] Despite concerns about the best measure for determining solute clearance, the Kt/V, which is the fractional urea clearance as a function of its volume of distribution, has been used widely as the measure for this assessment.[4] Over the years, single pool Kt/V of >1.2 has been used as the target DD, the amount that is just adequate to meet the needs of dialysis patients. Doses higher than this, as could be found in a 4-h thrice-weekly dialysis with high-flux dialysers, despite producing better waste removal, could be associated with excessive protein loss, early dialysis wasting, protein–energy malnutrition (PEM) and death.[5] The

Access this article online

Quick Response Code:

Website:
www.chs-journal.com

DOI:
10.4103/njhs.njhs_5_20

Address for correspondence: Dr. Uduagbamen PK,
Department of Internal Medicine, Division of Nephrology and
Hypertension, Ben Carson (Snr) School of Medicine, Babcock University,
Ilishan-Remo, Nigeria.
E-Mail: petr.uduagbamen@gmail.com

DD is said to be optimum at the amount above which no further noticeable benefit is seen without cost or adverse effect to the patient.[6] Despite the improvement in the DD in Nigeria over the years (from 45.3% ± 8.6% in 2003 to 57.83% ± 0.83% in 2015), majority of dialysis sessions are still largely inadequate when compared with what obtains in the developed nations.[7,8] Inadequate dialysis is associated with poor QOL, with frequent hospital admissions, increased morbidity and mortality.[9]

CONCLUSION

Even though there are many available literature on the adequacy of dialysis and its associates, inadequate DD is still a common occurence in several dialysis centres in many low-income settings. This is coupled with the fact that there could be wide socio-economic and educational differences between groups of dialysis population. We compared the dialysis sessions of participants in two centres with differences in socioeconomic and educational status in order to determine the DD, its clinical correlates and how it is impacted by differences in socioeconomic and educational class.

MATERIALS AND METHODS

This was a cross-sectional descriptive study carried out at the dialysis suites of two tertiary health centres in Southwestern Nigeria between August 2016 and December 2019.

Centre A was made up of participants, majority of whom belonged to the low socioeconomic class with less education and without institutional/governmental support, whereas centre B had a sizeable number of participants in the middle and higher socioeconomic classes, more education and full institutional coverage for all modalities of renal replacement therapy (RRT). Two hundred and thirty-two participants with ESKD, that is, with estimated glomerular filtration rate <15 ml/min and requiring RRT, who were receiving at least weekly maintenance haemodialysis (HD) for at least 1 month, who met study criteria and who had given informed consent, were consecutively recruited. Patients with urinary tract infection or any infection, tumour or renal graft were excluded. Sociodemographic data was taken. Pre-dialysis urinalysis was done on each visit to check for protein, blood and nitrite and rule out urinary tract infections.

The height and weight were taken without shoes and on very light clothing using a Seca 750 Mechanical Floor Scale (United Kingdom) and a Seca 274 Stadiometer (United Kingdom). Vital signs such as the temperature were taken and pre-dialysis pulse rate, blood pressure (BP) and percentage oxygen saturation were taken after participants had rested for 5 min. Dialysis prescription was written and vital signs were checked quarter-hourly throughout dialysis. Participants returning with either an arteriovenous fistula (AVF) or internal jugular vein (IJV) catheter had their access sites inspected for hyperaemia, warmness, skin excoriation or fluid discharge to rule out infection. With an IJV access, 1–2 ml of blood (and the locking fluid) was withdrawn and discarded to prevent diluting the pre-dialysis sample with the 'locking' antibiotic solution. Pre-dialysis samples were taken before flushing catheter lines with heparinised saline. Blood was taken from freshly sited femoral access (as part of our dialysis protocol). For AVF, samples were taken from a peripheral vein in the contralateral arm. Strict aseptic procedures were used in all sample collections.

Anticoagulation was with unfractionated heparin 5000 IU, and alterations were documented. Participants were connected, first through arterial and then venous portal. Where the blood flow and/or dialysate flow rate was altered intradialysis, the average was calculated. At the end of dialysis time, dialysate flow was stopped and blood flow was reduced to 100 ml/min. Five minutes after stopping the dialysate flow, blood was taken from arterial portal, first, for analysis of serum electrolytes (minimises access recirculation) and then packed cell volume. The urea reduction ratio (URR) was calculated from the formula = ([Pre-dialysis urea-post-dialysis urea]/post-dialysis urea) × 100 (>65.0%), and Kt/V (fractional urea clearance as a function of its volume of distribution) was calculated from Daugirdas second-generation logarithmic estimation of single pool (>1.2).[10]

Data were analysed using IBM SPSS Statistics 22 by SPSS Inc, Chicago, Illinois, United States of America. Continuous variables were presented as mean with standard deviation and compared using Student's *t*-test, whereas categorical variables were presented as proportions and compared using Chi-square test or Fisher's exact test. $P < 0.05$ was considered statistically significant. Where 3 or more variables needed to be compared, ANOVA was used. A multivariate logistic regression analysis was used to determine variables that independently predicted low DD.

ETHICAL CLEARANCE

This study was approved by the Human Ethics Committees of the Federal Medical Centre, Abeokuta and Babcock University, Ilishan-Remo (FMCA/470/HREC/03/2017, NHREC/08/10-2015) and (BUHREC/723/19, NHREC/24/01/2018) with approval dates of 3rd March 2017 and 23rd October 2019.

RESULTS

One thousand two hundred and forty-eight HD sessions for 232 participants were studied. The mean age of all participants was 49.9 ± 4.6 years: 48.3 ± 2.1 years for centre A and 51.2 ± 6.1 years for centre B. Table I shows the participants' characteristics, and a greater proportion of participants in centre A had glomerular disease (crescentic glomerulonephritis [CGN]) 35 (43.8%) unlike hypertensive nephrosclerosis 62 (40.8%) in centre B. The 40–59 years' age group had the largest proportion of participants in centre A, 39 (48.7%), and centre B, 72 (47.2%), followed by the young in centre, A 22 (27.5%), but elderly in centre B, 49 (32.2%). Four (5%) participants in centre A were fully sponsored by their

Table I: Sociodemographic, historical and anthropometric characteristics of participants

Variables	Centre A (n=80), n (%)	Centre B (n=152), n (%)	χ^2	P
Gender				
Males	55 (68.8)	88 (57.9)	2.6	0.03
Females	25 (31.2)	64 (42.1)		
Age (years)				
20–39	22 (27.5)	31 (20.4)	4.7	0.001
40–59	39 (48.7)	72 (47.4)		
≥60	19 (23.8)	49 (32.2)		
Aetiology of CKD				
Glomerulonephritis	35 (43.8)	53 (34.9)	3.2	0.002
Hypertension	28 (35.0)	62 (40.8)		
Diabetes	8 (10.0)	19 (12.5)		
Others	9 (11.2)	18 (11.8)		
Educational level				
Primary	14 (17.5)	6 (3.9)	7.3	<0.001
Secondary	32 (40.0)	43 (28.3)		
Tertiary	34 (42.5)	103 (67.8)		

CKD: Chronic kidney disease

Table II: Characteristics of the haemodialysis sessions

Variables	Centre A (n=418), n (%)	Centre B (n=830), n (%)	χ^2	P
Gender				
Males	292 (69.9)	526 (63.4)	2.2	0.04
Females	126 (30.1)	304 (36.6)		
Dialysis frequency/week				
<2	370 (88.5)	678 (81.7)	4.1	0.001
3	48 (11.5)	152 (18.3)		
Aetiology of CKD				
Glomerulonephritis	210 (50.2)	334 (40.2)	6.3	<0.001
Hypertension	140 (33.5)	378 (45.6)		
Diabetes	32 (7.7)	73 (8.8)		
Others	36 (8.6)	45 (5.4)		
Dialysis access				
Femoral	210 (50.2)	216 (26.0)	2.9	0.002
internal jugular	202 (48.3)	555 (66.9)		
AVF	6 (1.5)	59 (7.1)		
Dialysis duration, h				
<4	57 (13.6)	72 (8.7)	1.9	0.04
4	361 (86.4)	758 (91.3)		
Dialysers type				
High flux	407 (97.4)	822 (99.0)	3.3	0.002
Low flux	11 (2.6)	8 (1.0)		
BFR, ml/min				
≥350	93 (22.2)	774 (93.3)	4.4	0.001
200-350	325 (77.8)	56 (6.7)		
Ultrafiltration volume, L				
≥2	152 (36.4)	217 (26.1)	0.2	0.02
≤2	266 (63.6)	613 (73.9)		

CKD: chronic kidney disease, AVF: Arteriovenous fistula, BFR: Blood flow rate

organisations as against 52 (34.2%) in centre B. The percentage of participants with tertiary education in centre A (42.5%) was less compared to centre B 103 (67.8%). Table II shows the dialysis sessions of participants. The mean dialysis session for females in centre A, 5.0 ± 0.5, was higher than for females in centre B, 4.7 ± 0.3.

Table III shows the dialysis outcome of the two centres. The percentage of intradialysis complications was higher in centre A (54.0%) compared to centre B (38.9%). Both centres recorded an episode of intradialysis cardiac arrest on background intradialysis hypertension. The proportion of sessions with adequate dialysis was less with Kt/V 115 (9.2%) compared to URR 152 (12.2%). Using the Kt/V, the percentage of adequate dialysis delivered in centre A was 6.7% compared to 10.5% in centre B, and using the URR, it was 8.6% in centre A compared with 14.2% in centre B.

The anthropometric, laboratory and dialysis characteristics of the participants in the two centres are shown in Table IV. Participants that had three sessions weekly in centre A had a total of 48 (11.5) sessions compared to 152 (18.3) in centre B. The mean pre-dialysis creatinine for centre A was significantly higher than for centre B, $P = 0.001$. The mean blood flow rate (BFR) for centre A was significantly lower than for centre B, $P < 0.001$. The mean dialysis duration for participants in centre A was significantly lower than for centre B, $P = 0.04$. The mean ultrafiltration volume for centre A was more than for centre B, but the difference was insignificant, $P = 0.5$. The determinants of low DD for the two centres are shown in Table V. BFR <250 ml/min, dialysis duration <4 h and femoral catheterisation were more likely to give inadequate dialysis in centre A than in centre B, $P < 0.001$, $P < 0.001$ and $P < 0.001$, respectively.

A multivariate analysis was conducted using variables from univariate analysis to determine variables that independently predicted inadequate dialysis, as shown in Table VI. BFR (odds ratio [OR] – 0.03, 95% confidence interval [CI] – 0.023–0.034), dialysis duration (OR – 3.32, 95% CI – 3.22–3.48) and femoral catheterisation (OR – 0.02, 95% CI - 0.01–0.04) predicted DD in the study.

DISCUSSION

We studied the adequacy of dialysis in two centres, determined the factors responsible for poor dialysis delivery and ascertained the causes of wide inter-centre variations. A Kt/V of >1.2 and a URR of >65% are National Kidney Foundation Kidney Disease Outcomes Quality Initiative 2006's recommended global target set for adequacy of dialysis for optimal patient response.[11] The DD was adequate in 6.7% of HD sessions in centre A and 10.5% in centre B. The mean DD, though still very low, has slowly increased over the years in Nigeria.[7,8] Furthermore, findings from another developing country showed URR ranging from 55% to 65%.[12] The mean DD in this study is lower than in Europe and North American from where the United State Renal Registry reported a Kt/V

Table III: Dialysis events and outcome in the two centres

Variables	All (n=1248), n (%)	Mean±SD		P
		Centre A (n=418)	Centre B (n=830)	
IDH	242 (19.4)	108±25.8	134±16.1	0.03
IDHT	305 (24.4)	116±27.8	189±22.8	
URR (%)				
Normal (>65)	154 (12.3)	36±8.6	118±14.2	0.001
Low (<65)	1094 (87.7)	382±91.4	712±85.8	
Kt/V				
Normal (>1.2)	115 (9.2)	28±6.7	87±10.5	0.002
Low (<1.2)	1133 (90.8)	390±93.3	743±89.5	
Mean URR (%)	55.8±4.0	51.7±4.2	57.9±3.9	0.001
Mean Kt/V	1.02±0.4	0.86±0.2	1.11±0 5	0.002

SD: Standard deviation, URR: Urea reduction ratio, IDH: Intradialysis hypotension, IDHT: Intradialysis hypertension, CKD: Chronic kidney disease

Table IV: Comparing patients' characteristics in centres A and B

Variables	Mean±SD		t-test (χ^2)	P
	Centre A	Centre B		
Mean age, years	48.3±2.1	51.2±6.1	1.6	0.03
Females	126 (30.1)	304 (36.6)	1.4	0.04
Males		292 (69.9)	526 (63.4)	
Mean pre-dialysis SBP, mmHg	168.2±5.6	178. 5±4.2	1.4	0.003
Mean PD SPO$_2$, (%)	93.1±8.4	94.8±22.3	1.2	0.04
Mean PD urea, mmol/l	16.4±2.3	12.2±3.6	5.4	<0.001
Mean PD creatinine, umol/l	588.4±23.6	523.8±23.6	3.6	0.001
Mean PD eGFR, ml/min	4.6±1.1	6.6±2.1	2.2	0.03
Mean BFR, ml/min	289.6±27.1	342.7±11.4	7.6	<0.001
Mean ultrafiltration volume, L	1.3±0.6	1.1±1.0	0.7	0.5
Mean dialysis duration, h	3.4±1.2	3.9±2.2	1.5	0.04

SD: Standard deviation, PD: Pre-dialysis, SPO$_2$: Oxygen saturation, SBP: Systolic blood pressure, BFR: Blood flow rate, eGFR: Estimated glomerular filtration rate

of >1.2 in more than 90% of dialysis sessions.[13] More males participated in the study, similar to other studies in Nigeria and other sub-Sahara Africa, where chronic kidney disease (CKD) is known to be more common in males.[2,7]

This male preponderance can be attributed, in parts, to the relative gender bias in accessing health care and cultural and traditional practices.[14] Males are more likely to suffer progressive kidney injury even under renin-angiotensin-aldosterone system (RAAS) blockage as a result of the fact that males are less sensitive to RAAS blockage as reported by Miller *et al.*[15] and they experience a worsening of this response after 8 weeks of RAAS blockage. Males received higher DDs

than females in this study. El-Sheikh and El-Ghazaly[16] reported higher Kt/V amongst males in Egypt. However, another study reported a lower DD in males compared to females. [17] Despite larger muscle and body mass, males have less volume of distribution due to reduced body fat compared to females. Urea clearance is inversely related to its distribution volume, hence increasing clearance in males. The finding of higher DD in the older population in this study agrees with other studies in Europe.[18] Comorbidities in the older participants would reduce the DD, but the combined effect of higher BFR, longer dialysis duration and fewer intradialysis complications tends to override the effect in this study.

Infectious causes of CKD like CGN were more amongst participants in centre A compared to centre B who were more likely to treat infections earlier and better. Infectious causes of CKD are more common in low-income nations compared to the advanced nations.[2,7] There was an overall direct relationship between body mass index (BMI) and DD in this study, and this disagrees with Depner *et al.* who reported an inverse relationship between the DD and the BMI.[19] Considering the negative association between obesity, metabolic syndrome, increased levels of inflammatory and atherogenic forms of low-density lipoproteins, and the DD, only the combined effect of more IJV catheterisation, higher BFR, albumin and lesser intradialysis complications in centre B could have override this negative correlation.

Acidosis is a cause and effect of low DD. The presence and severity of acidosis was a strong determinant of low DD, which agrees with Meyring-Wosten *et al.*[20] findings. It disrupts the Alveolar-arterial oxygen difference (A-a D0$_2$) and, if severe, overwhelms the buffering effects of bicarbonate and hydrigen ions and causes systemic vasodilation with concurrent pulmonary vasoconstriction and hypertension. This can precipitate right ventricular failure and bone calcium loss as a result of the body's attempt to augment buffering. Intradialytic hypotension can result from vasodilatation and cutaneous and peripheral pooling with low cardiac output. However, the effect of acidosis is seen less these days with the use of bicarbonate buffers coupled with intradialytic HCO$_3$ generation which lessens the degree and consequences of acidosis.

At presentation for dialysis, participants from centre A had worse derangement in electrolytes compared with those from centre B. Hyperkalaemia results from a complex interplay of many pathophysiologic processes, with reduced tubular secretory defects of the principal and intercalated cells, defective N$^+$ K$^+$ ATPase activity, hyporeninaemic hypoaldosteronism-associated type 4 renal tubular acidosis and RAAS inhibition.[21] Hyperkalaemia reduces cellular transmembrane K$^+$ gradient and its effect on the membrane potential. A U-shaped association exists between the pre- and post-dialysis serum potassium with increased risk of intradialysis sudden cardiac death, with lowest risk reported at 5 mmol/l and higher risk at <5 mmol/l and >5 mmol/l.[21]

Table V: Determinants of Inadequate dialysis from pre-dialysis variables amongst participants

Variables	Mean±SD			P (ANOVA)
	All sessions Kt/V≥1.2 (*n*=115), *n* (%)	Centre A Kt/V<1.2 (*n*=390), *n* (%)	Centre B Kt/V<1.2 (*n*=743), *n* (%)	
Females	26 (22.6)	120 (30.7)	284 (38.2)	0.04
Age >60 years	24 (20.9)	72 (18.5)	295 (39.7)	0.02
SBP >140 mmHg	67 (28.3)	334 (85.6)	708 (95.3)	0.002
BFR <250 ml/min	8 (7.0)	108 (27.7)	111 (15.0)	<0.001
Duration <4 h	1 (0.9)	57 (14.6)	23 (3.1)	<0.001
Femoral access	5 (4.3)	209 (53.6)	212 (28.5)	<0.001
<2 HD/weeks	3 (0.2)	194 (46.4)	93 (12.5)	0.002
UFV <1L	26 (22.6)	88 (22.6)	175 (23.6)	0.06

BFR: Blood flow rate, UFV: Ultrafiltration volume, HD: Haemodialysis, SD: Standard deviation, SBP: Systolic blood pressure

Table VI: Multivariate regression analysis

Variable	OR	95% CI	P
Females	3.43	2.98-3.74	0.05
Age	1.68	1.05-2.66	0.06
BFR <350 ml/min	0.03	0.028-0.034	0.04
Dialysis duration <4 h	3.32	3.22-3.48	0.01
Femoral catheterisation	0.02	0.01-0.04	0.03
Frequency of dialysis	0.06	0.05-0.08	0.06
Diabetes	1.74	1.28-2.12	0.05

OR: Odd ratio, CI: Confidence interval, BFR: Blood flow rate

Hyperphosphataemia with hypocalcaemia is a common finding in CKD (though the pattern might change as disease progress to end stage), associated with hyperparathyroidism. Elevated calcium-phosphate product increases the risk of progressive vascular calcification, CKD bone mineral disorder (CKD-BMD) and mortality.[22] The combination of low phosphate-to-protein meal (vegetables and egg white), dialysis and the use of phosphate binders is needed for effective control of hyperphosphataemia as most of the $PO4^{2-}$ is intracellular and sequestrated, limiting its removal in routine 4-h dialysis. This emphasises the need for compliance with the Kidney Disease Improving Global Outcomes (KDIGO) recommendation regarding the periodic measurement of Ca-Po4 (1–3 monthly), parathyroid hormone (3–6 monthly), serum alkaline phosphatase (annually in Stages 4 and 5 with dialysis) or more frequently with elevated PTH.[23]

The lower the level of pre-dialysis nitrogenous waste, the lesser the intradialysis osmotic gradients (differences between pre- and expected post-dialysis levels). In patients at risk of disequilibrium syndrome, even though rare, persistently low waste retention substantially reduces this risk.[24] There was a direct relationship between the haematocrit and the DD in this study similar to findings reported by Movilli *et al.*[25] Anaemia is commonly associated with hypoxaemia, PEM and high interdialytic weight gain necessitating higher ultrafiltration from increased extraction ratio.

There was a direct relationship between ultrafiltration volume, dialysis duration, tunnelled IJV, A-V fistula, BFR and DD in this study. Ultrafiltration helps in removing retained fluid in addition to the nitrogenous waste dissolved in the fluid removed, hence its advantage considering the intradialysis generation of urea and other nitrogenous waste. Although greater ultrafiltration is achieved during the first 2 h, more solutes in increasing order of weight are removed as the dialysis continues.[26] The higher DD found with the tunnelled catheters apart from, the higher BFR could also be attributable to the absence of fibrous tissues, catheter movement or dislodgement and lesser infection rates compared to the femoral catheters.[27] However, persistent dialysis high blood flow increases the risk for excessive protein loss, PEM, dialysis cachexia and anaphylactic reactions and death.[28] The use of larger surface dialysers was associated higher DD in this study similar to findings by Teixeire *et al.*[28] Larger dialysers allow for higher blood flow within dialyser compartment, generation of intercompartmental gradient and greater diffusion resulting in higher solute clearance.

The differences in the mean DD for the two centres in this study are related to the frequency of dialysis, frequency of erythropoietin use, higher educational and socioeconomic status and overall level of compliance with treatment modalities. Apart from the educational status, other factors had a direct bearing with the full sponsorship for dialysis that was disproportionally in favour of participants in centre B. This again underscores the importance of governmental and institutional assistance to the teaming CKD population in Nigeria and other low-income countries since the majority of the populace cannot afford dialysis treatment.[29,30]

Being a two-centre study, it brought to the fore, even in the context of a low-income country, the impact of differences in socioeconomic and educational gap on the delivered DD. Limitations encountered included the possible presence of some unidentified comorbidities that could be confounders. The contribution of the residual kidney function and the dry weight of the participants were not determined; again, there could be some irregularities with dialysis intervals.

The prevalence of inadequate dialysis is still very high as only 9.2% of the dialysis sessions in this study met the global

targets of Kt/V > 1.2. The patient factors that were identified as predictors of low DD were low socioeconomic and educational background, low PCV and low albumin, and the non-patient factors were shorter dialysis duration and intradialysis complications. The effects of these can, however, be mitigated by the use of tunnelled IJV, A-V fistula, higher BFRs, frequent erythropoietin use and frequent dialysis. Government and cooperate organisation involvement in renal care would go a long way in improving dialysis outcome.

We recommend that dialysis staff should be enlightened on the need to adhere as much as possible to dialysis prescription and that nephrologists should seek to optimally prepare their patients for dialysis by improving the BP control, correction of anaemia and reduction of intradialysis complications. There is the need for more involvement by the government, private sector, philanthropists and religious bodies in funding renal care in Nigeria.

Acknowledgement

Financial support and sponsorship

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. National Kidney Foundation. K/DOQI clinical practice guidelines for chronic kidney disease: Evaluation, classification, and stratification. Am J Kidney Dis 2002;39:S1-266.
2. Arije A. Problems of haemodialysis in the management of chronic renal failure in Ibadan. Arch Ibadan Med 2001;2:14-6.
3. Churchill DN. An evidence based medicine approach to determining the adequacy of peritoneal dialysis. Nephrology 1996;2 Suppl 1:S155-8.
4. Abdul A, Naiker S. Assessment of peritoneal dialysis adequacy – Does it impact on patient outcomes? Tropical J Nephrol 2011;6:5-10.
5. Teehan BP, Schleifer CR, Brown J. Assessment of dialysis adequacy and nutrition by urea kinetic modeling. Perit Dial Int 1994;14 Suppl 3:S99-104.
6. Depner TA. Hemodialysis adequacy: Basic essentials and practical points for the nephrologist in training. Hemodial Int 2005;9:241-54.
7. Agaba EI, Lopez A, Ma I, Martinez R, Tzamaloukas RA, Vanderjagt DJ, et al. Chronic hemodialysis in a Nigerian teaching hospital: Practice and costs. Int J Art Organs 2003;26:991-5.
8. Yeldu MH, Makusidi MA, Mainasara AS, Bassi PU, Erhabor O. Assessment of haemodialysis among ESRD in Sokoto, using URR and serum albumin. Asian J Sci Tech 2015;6:1044-50.
9. Lowrie EG, Laird NM, Parker TF, Sargent JA. Effect of the hemodialysis prescription of patient morbidity: Report from the National Cooperative Dialysis Study. N Engl J Med 1981;305:1176-81.
10. Daugirdas JT. Second generation logarithmic estimates of single-pool variable volume Kt/V: An analysis of error. J Am Soc Nephrol 1993;4:1205-13.
11. National Kidney Foundation-KDOQI 2006 Updates Clinical Practice Guildelines and Recommendations. Hemodialysis Adequacy. Peritoneal Dialysis Adequacy. Vascular Access; 2006. p. 1-183.
12. Amini M, Aghighi M, Masoudkabir F, Zamyadi M, Norouzi S, Rajolani H, et al. Hemodialysis adequacy and treatment in Iranian patients: A national multicenter study. Iran J Kidney Dis 2011;5:103-9.
13. ESRD Annual Report. Critical performance measure project. Am J Kidney Dis 2007;51 Suppl 1:S1.
14. Ulasi I. Gender bias in access to healthcare in Nigeria: A study of end-stage renal disease. Trop Doct 2008;38:50-2.
15. Miller JA, Chernet DZ, Duncan JA, Lai V, Burns KD, Kennedy CR, et al. Gender difference in the renal responses to Renin Angiotensin System Blockage. JASN 2006;17:2554-60.
16. El-Sheikh M, El-Ghazaly G. Assessment of hemodialysis adequacy in patients with chronic kidney disease in the hemodialysis unit at Tanta University Hospital in Egypt. Indian J Nephrol 2016;26:398-404.
17. Somji SS, Ruggajo P, Moledina S. Adequacy of Hemodialysis and Its Associated Factors among Patients Undergoing Chronic Hemodialysis in Dar es Salaam, Tanzania. International Journal of Nephrology. 2020 ; 2020:9863065. https://doi.org/10.1155/2020/9863065.
18. U.S. Renal Data System: United States Renal Data System 2006 annual data report atlas of chronic kidney disease & end-stage renal disease in the United States. Am J Kidney Dis 2007;49:1-296.
19. Depner T, Daugirdas J, Greene T, Allon M, Beck G, Chumlea C, et al. Dialysis dose and the effect of gender and body size on outcome in the HEMO Study. Kidney Int 2004;65:1386-94.
20. Meyring-Wösten A, Zhang H, Ye X, Fuertinger DH, Chan L, Kappel F, et al. Intradialytic Hypoxemia and Clinical Outcomes in Patients on Hemodialysis. Clin J Am Soc Nephrol. 2016 Apr 7;11(4):616-25.
21. Kovesdy CP, Regidor DL, Mehrotra R, Jing J, McAllister CJ, Greenland S, et al. Serum and dialysate potassium concentration and survival haemodialysis patients. Clin J Am Soc N 2007;2:999-1007.
22. Sanusi AA, Arogundade FA, Oladigbo M, Ogini LM, Akinsola A. Prevalence and pattern of renal bone disease in end stage renal disease patients in Ile-Ife, Nigeria. West Afr J Med 2010;29:75-80.
23. Ketteler M, Block GA, Evenepoel P, Fukugawa M, Herzog CA, McCain L, et al. Executive summary of the 2017 KDIGO Chronic Kidney Disease-Mineral and Bone Disoder CKD-MBD (Guidelines Update): What changed and why it matters. Kidney Int 2017;92:26-36.
24. Gotch FA, Sargent JA. A mechanistic analysis of the National Cooperative Dialysis Study (NCDS). Kidney Int 1985;28:526-34.
25. Movilli E, Cancarini GC, Zani R, Camerini C, Sandrini M, Maiorca R. Adequacy of dialysis reduces the doses of recombinant erythropoietin independently from the use of biocompatible membranes in haemodialysis patients. Nephrol Dial Transplant 2001;16:111-4.
26. Eknoyan G, Beck GJ, Cheung AK, Daugirdas JT, Greene T, Kusek JW, et al. Effect of dialysis dose and membrane flux in maintenance hemodialysis. N Engl J Med 2002;347:2010-9.
27. III. NKF-K/DOQI Clinical practice guidelines for vascular access: Update 2000. Am J Kidney Dis 2001;37:S137-81.
28. Teixeira NF, de Campos G, Xavier de Paula SM, Merchi VA, Portero-Mclellan KC, da Motta DG, et al. Dialysis adequacy and nutritional status of hemodialyzed patients. Hemodial Int 2008;12:45-51.
29. Arogundade FA, Barsoum RS. Chronic kidney disease in sub Saharan African: A call for government, non-governmental and community support. Am J Kidney Dis 2008;51:515-23.
30. Ajayi S, Salako BL. Unaffordability of renal replacement therapy in Nigeria. Hong Kong J Nephrol 2016;18:15-9.