

Original Research Article

Comparison of urea reduction ratio and dialysis efficacy in evaluating haemodialysis adequacy in chronic kidney disease patients in Wangaya Hospital

Katarina D. Sartika*, I. Wayan Sunaka

Department of Internal Medicine, Wangaya Hospital, Denpasar, Bali, Indonesia

Received: 06 July 2022

Revised: 29 July 2022

Accepted: 30 July 2022

*Correspondence:

Dr. Katarina D. Sartika,

E-mail: katarinadewisartika@gmail.com

Copyright: © the author(s), publisher and licensee Medip Academy. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

ABSTRACT

Background: An increasing number of patients with chronic kidney disease (CKD) impact an increased need for hemodialysis. Inadequate hemodialysis affects morbidity in patients with CKD. Determination of the urea removal index can be accomplished by several invasive and non-invasive methods. The purpose of this study was to compare the urea reduction ratio (URR) and dialysis efficiency (Kt/V) calculated automatically by hemodialysis machines to assess the adequacy of hemodialysis in patients with CKD.

Methods: A cross-sectional analysis study was conducted on 58 CKD patients with age ≥ 18 years, conventional 5-hour hemodialysis sessions twice weekly, using single use-hollow fiber dialyzers, and who had been receiving hemodialysis for ≥ 6 months in the hemodialysis unit at Wangaya Hospital from April 2022 to May 2022. Study data were obtained from medical records then described and analyzed using the statistical package for the social sciences (SPSS) program.

Results: The mean of URR was 70.74 ± 10.04 , while the mean of Kt/V delivered by machine was 1.27 ± 0.19 . More hemodialysis patients received adequate hemodialysis based on URR parameters compared to Kt/V parameters (84.5% versus 1.7%). There was no significant difference between age, sex, body mass index (BMI), comorbidities, vascular access and duration of dialysis with adequacy hemodialysis. There was a significant difference between URR and Kt/V in the evaluation adequacy of hemodialysis ($p=0.000$). In addition, there was a positive correlation between URR and Kt/V in the evaluation adequacy of hemodialysis ($r=0.592$, $p=0.000$).

Conclusions: The URR is a more accurate parameter, but the Kt/V delivered by machine can help the URR demonstrate the adequacy of haemodialysis patients with CKD.

Keywords: Adequacy of hemodialysis, CKD, URR, Kt/V

INTRODUCTION

An increasing number of patients with chronic kidney disease (CKD) has become a global health problem. According to data from the United States renal data system, it is estimated that in 2010 around 2.6 million CKD patients from almost all over the world have undergone hemodialysis and it will increase two-fold by 2030.¹ Meanwhile, according to RISKESDAS data in 2013 in Indonesia, 2 per 1000 population or 499.800

people diagnosed with kidney disease and still increase until 2018 reaching 713.783 people. Province of Bali ranks second after DKI Jakarta for the province with the most CKD disease.²

Urea is waste product in the blood and in the high levels of urea mean that more dangerous. Hemodialysis is a transport process in which a solute passively diffuses down its concentration gradient from one fluid compartment (either blood or dialysate) to another.³ The purpose of

hemodialysis is to remove toxins from the body and keep their intracellular and extracellular composition within normal limits.⁴ The dose of hemodialysis must be adequate to improve quality of life and to prolong survival.⁵ Several studies have shown increased morbidity and mortality in patients with inadequate hemodialysis.⁶ To determine whether dialysis is adequate to excrete urea, the dialysis unit must periodically do the dialysis assessment.⁷

Urea removal index is the key in evaluating hemodialysis adequacy. Various formulas such as urea reduction ratio (URR) or Kt/V are effective.⁸ According to kidney guidelines disease outcomes quality initiative (KDOQI), the approved method for calculating Kt/V is the Daugirdas formula, and the KDOQI guidelines recommend that the Kt/V should be kept above 1.2 or URR 65% for thrice weekly routine hemodialysis.⁹ Indonesia renal registry recommends the target Kt/V is 1.8 for twice weekly hemodialysis and Kt/V is 1.2 for thrice weekly hemodialysis.¹⁰ Real-time monitoring of the measured Kt/V on the screen of the hemodialysis machine is non-invasive method and cost-effective to evaluation adequacy of hemodialysis.¹¹ The hemodialysis machine will automatically calculate the measured sodium ion clearance based on the plasma conductivity.¹² The aim of the study was to compare the adequacy of hemodialysis based on URR and Kt/V delivered by the machine and its correlation.

METHODS

This study protocol was approved by health research ethics committee, Wangaya Hospital (Denpasar, Bali, Indonesia) with approval number 032/III.4/KEP/RSW/2022. This was a cross sectional analysis study including CKD patients with age ≥ 18 years, conventional 5-hour hemodialysis sessions twice weekly, using single use-hollow fiber dialyzers, and who had been receiving hemodialysis for ≥ 6 months in the hemodialysis unit Wangaya Hospital (Denpasar, Bali, Indonesia) from April 2022 to May 2022. The exclusion criteria were patient lost to follow up and incomplete medical records. The minimum sample size for this study was 58 subjects.

The demographic data, comorbidities, type of vascular access and duration of dialysis were obtained from medical record. Age, sex, body mass index, comorbidities, type of vascular access, duration of hemodialysis and adequacy hemodialysis were reported as the frequency (percentage). URR and Kt/V were reported as the mean $\pm$ standard deviation. The Chi-square and Fisher test were used for bivariate analysis. URR and Kt/V was compared with the Mann Whitney test. The correlations between URR and Kt/V were evaluated by the Spearman test. All statistical analysis were analysed using statistical package for the social sciences (SPSS) program for Mac version 26. The p value < 0.05 was considered significant.

Adequacy hemodialysis was measured by two parameters. The first parameter was the common method using URR.

Two blood samples were taken from each patient before and after at the same session of hemodialysis, blood sample before hemodialysis taken from the needle arteries before salt contamination or heparin and blood sample after hemodialysis taken from arterial line around 2 minutes after Qb is lowered by 50 ml/min.¹³ URR was calculated using the formula given.

$$URR = 100 \times (1 - Ct/Co)$$

Where, Ct is BUN after hemodialysis and Co is BUN before hemodialysis. In the second parameter, Kt/V was calculated automatically using Nipro Surdial +55 dialysis machine with Nipro Elisio-15H dialysate by online clearance monitoring. This method was based on measuring the difference between the plasma conductivity and the difference in electrolytes concentration of this fluid. Sodium ions represent the largest proportion of electrolyte in the dialysis fluid and their concentration basically determines the total conductivity of the dialysis fluid. Although the sodium ion differs from the urea molecule, both particles demonstrate comparable *in vitro* and *in vivo* diffusion characteristics across a synthetic dialysis membrane. For that reason, the urea clearance can be defined by calculating the sodium ion clearance. This method is non-invasive, easy and inexpensive.¹² In Kt/V, K is dialyzer clearance (ml/min or l/hour), t is time (min or hour), and V is distribution volume of urea (ml or l).

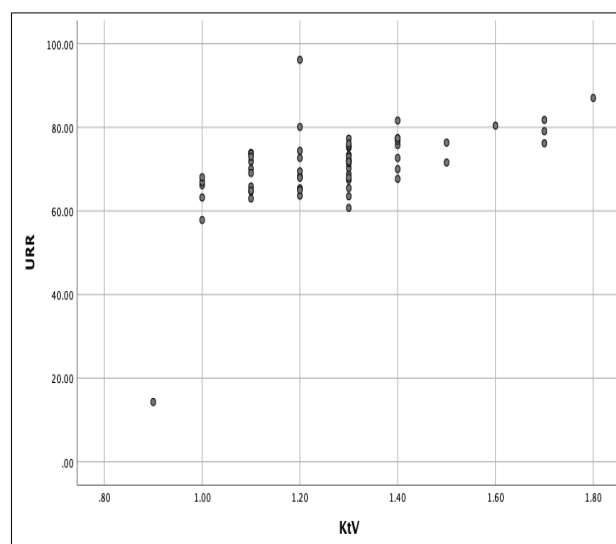
RESULTS

Screening on 71 hemodialysis patients at Wangaya Hospital and 13 patients were excluded (3 patients died and 10 patients undergoing hemodialysis less than 6 months). Fifty-eight patients meet the inclusion criteria. There were 43 male (74.1%) and 15 female (25.9%). The mean $\pm$ SD age was 54.26 $\pm$ 14.95 years. The mean $\pm$ SD of body mass index was 22.45 $\pm$ 3.17. The mean $\pm$ SD duration of dialysis was 4.59 $\pm$ 2.92 years. Hypertension was the most comorbid in this study (56.9%). Although the most commonly used vascular access is permanent access (93.1%) (Table 1). The proportion of patients receiving adequate hemodialysis in Wangaya Hospital based on URR was 84.5% and based on Kt/V was 1.7% (Table 2). There was no significant difference between age, sex, BMI, comorbidities, vascular access and duration of dialysis with adequacy hemodialysis based on URR or Kt/V (Table 3). The mean $\pm$ SD of URR was 70.74 $\pm$ 10.04 and the mean $\pm$ SD of Kt/V was 1.27 $\pm$ 0.19.

The results of the comparative analysis showed a significant comparison between URR and Kt/V in the evaluation of hemodialysis adequacy with p value=0.000 (Table 4). Furthermore, we analyzed the correlation between URR and Kt/V in evaluating the adequacy of hemodialysis. There was a significant correlation between URR and Kt/V (p value=0.000, r=0.592). The correlation between URR and Kt/V was positive, which means the increase/decrease of URR will be in line with the increase/decrease of Kt/V (Figure 1).

Table 1: Demographic and clinical subject characteristics.

Characteristics	N	%
Age (years)		
<60	37	63.8
≥60	21	36.2
Sex		
Male	43	74.1
Female	15	25.9
Body mass index (kg/m²)		
Underweight	8	13.8
Normal	27	46.6
Overweight	23	39.7
Comorbidities		
Hypertension	33	56.9
Diabetes mellitus	16	27.6
Coronary artery disease	2	3.4
Chronic pyelonephritis	9	15.5
Chronic glomerulonephritis	5	8.6
SLE	1	1.7
Vascular access		
Permanent	54	93.1
Temporary	4	6.9
Duration of hemodialysis (years)		
≤1	9	15.5
>1	49	84.5

**Figure 1: Correlation of the two parameters. The x-axis is the Kt/V calculated by machine dialysis the y-axis is the URR.****Table 2: Adequacy hemodialysis based on URR and Kt/V.**

Adequacy hemodialysis	n	Adequate (%)	Inadequate (%)
URR	58	49 (84.5)	9 (15.5)
Kt/V	58	1 (1.7)	57 (98.3)

Table 3: Subject characteristics and associate factors with adequacy hemodialysis.

Factors	URR N (%)		P value	Kt/V N (%)		P value
	Adequate	Inadequate		Adequate	Inadequate	
Age (years)						
<60	30 (81.1)	7 (18.9)	0.465	1 (2.7)	36 (97.3)	1.0
≥60	19 (90.5)	2 (9.5)		0	21 (100)	
Sex						
Male	35 (81.4)	8 (18.6)	0.422	0	43 (100)	0.259
Female	14 (93.3)	1 (6.7)		1 (6.7)	14 (93.3)	
Body mass index (kg/m ²)						
Underweight	8 (100)	0	0.552	0	8 (100)	0.534
Normal	22 (81.5)	5 (18.5)		0	27 (100)	
Overweight	19 (82.6)	4 (17.4)		1 (4.3)	22 (95.7)	
Comorbidities						
Hypertension	27 (81.8)	6 (18.2)	0.718	1 (3)	32 (97)	1.0
Diabetes mellitus	14 (87.5)	2 (12.5)	1.0	0	16 (100)	1.0
Coronary artery disease	2 (100)	0	1.0	0	2 (100)	1.0
Chronic pyelonephritis	9 (100)	0	0.328	0	9 (100)	1.0
Chronic glomerulonephritis	5 (100)	0	1.0	0	5 (100)	1.0
SLE	0	1 (100)	0.155	0	1 (100)	1.0
Vascular access						
Permanent	45 (83.3)	9 (16.7)	0.379	1 (1.9)	53 (98.1)	1.0
Temporary	4 (100)	0		0	4 (100)	
Duration of haemodialysis (years)						
≤1	6 (66.7)	3 (33.3)	0.136	0	9 (100)	1.0

Continued.

Factors	URR N (%)		P value	Kt/V N (%)		P value
	Adequate	Inadequate		Adequate	Inadequate	
>1	43 (87.8)	6 (12.2)		1 (2)	48 (98)	

Table 4: Comparison of URR and Kt/V in the evaluation hemodialysis adequacy.

Variable	N	Mean±SD	Median	Min-max	P value
URR	58	70.74±10.04	71.7	14.29-96.13	0.000
Kt/V	58	1.27±0.19	1.3	0.9-1.8	

DISCUSSION

From 58 subjects in this study, hemodialysis adequacy based on the URR parameter shows more adequate results than the Kt/V parameter. The Kt/V recommendation is 1.8 for hemodialysis patients twice weekly, but based on experience twice weekly hemodialysis sessions has resulted in sufficient Kt/V (≥ 1.2) and patients also feel more comfortable. In addition, the availability of health insurance funds in Indonesia is limited and only cover hemodialysis sessions twice weekly. Therefore, at Wangaya General Hospital, hemodialysis is usually provided twice weekly for 5 hours or based on individual needs. The frequency and blood flow of dialysis are strongly related to the adequacy of hemodialysis based on spKt/V and URR. Thus, to achieve adequate hemodialysis, it is recommended to increase the frequency of dialysis from two to three sessions per week.¹⁴

There was no significant difference between age, sex, BMI, comorbidities, vascular access and duration of dialysis with adequate hemodialysis based on URR or Kt/V parameters. Similarly, study from Shariati et al that reported no significant difference between age and adequacy of hemodialysis. However, a study by Anees et al showed that hemodialysis adequacy decreased with age.¹⁵ It seems that differences in sampling methods and the sample size were the cause of the differences. Tayyebi et al also reported no significant difference between sex and adequacy of hemodialysis.¹⁶

However, a study conducted by Rezaiee et al showed that there was significant difference between gender and adequacy of hemodialysis where female had better hemodialysis adequacy than male.¹⁷ These differences occur due to differences in the distribution of sex in various studies. Similar with the study of Somji et al and Utami et al reported no significant difference between BMI and hemodialysis adequacy.^{8,18} Nevertheless, the study by Nunes et al showed a negative correlation between hemodialysis adequacy and BMI, which means that the higher the hemodialysis adequacy, the lower the BMI.¹⁹ BMI influenced body surface area, where patients with low BMI will tend to have a smaller body surface area which causes more optimal urea clearance. Similarly, Somji et al also reported that there was no significant difference between the underlying disease and adequacy of hemodialysis.⁸ Rezaiee et al and Shariati et al reported no significant difference between vascular access and

hemodialysis adequacy.^{17,20} However, other studies have shown that temporary vascular access has a negative impact on hemodialysis adequacy. It is necessary to perform further study involving the distribution of patients with the same vascular access. Roozitalab et al also reported no significant difference between duration of dialysis and adequacy of hemodialysis.²¹

Although, Rezaiee et al reported that there was significant difference between duration of dialysis and adequacy of hemodialysis.¹⁷ Longer duration of hemodialysis increased patient adaptation to the hemodialysis process and higher hemodialysis adequacy. The differences that occur in this study were influenced by a wide range of hemodialysis duration.

The results of the comparative analysis showed a significant comparison between URR and Kt/V in the evaluation of hemodialysis adequacy with p value=0.000. The URR parameter is more accurate in assessing urea removal due to dialysis based on a mathematical calculation model. However, the URR parameter has difficulties such as requiring medical staff and increased costs associated with processing and analyzing blood samples. Meanwhile, Kt/V is a parameter of the amount of plasma cleared urea ($K \times t$) divided by K is dialyzer clearance of urea (expressed in litres per hour), t is dialysis active time (expressed in hours), and V is urea distribution volume (expressed in litres).²² A study by Kim et al reported that the machine calculation method can accurately assume the adequacy of hemodialysis using continuously measured data from the hemodialysis machine.²³

Furthermore, there is a correlation between URR and Kt/V ($r=0.592$, p value=0.000). The relationship between URR and Kt/V is positive, which means the increase/decrease in URR will be in line with the increase/decrease in Kt/V. This is supported by the findings of Baloglu et al who evaluated the adequacy of hemodialysis with several parameters showing that the Kt/V calculated by the Daugirdas formula without considering UF was similar to the Kt/V measured on the machine. However, the analysis of the correlation between Kt/V calculated using the Daugirdas formula and URR was more statistically significant.¹²

This study has several limitations, including data on several factors that directly affect hemodialysis doses such

as quick of blood, average ultrafiltration, duration of each dialysis session as well as several confounding factors for Kt/V such as albumin, inflammatory markers (CRP and ferritin) and function residual kidney was not included in this study.

CONCLUSION

Evaluation of hemodialysis adequacy based on URR parameters showed hemodialysis patients at Wangaya Hospital had received adequate hemodialysis compared to Kt/V parameters. There is a significant difference between URR and Kt/V parameters in the evaluation of hemodialysis patients. URR and Kt/V parameters have positive correlation in the evaluation of hemodialysis of patients with CKD. URR is a more accurate parameter for calculating hemodialysis adequacy. However, the Kt/V delivered by machine can be used as a practical tool that can help the URR to demonstrate hemodialysis adequacy.

ACKNOWLEDGEMENTS

Authors would like to thank Ketut Suryana as chairman of Internal Medicine Department, all the participants and the hemodialysis group staff who supported this study.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

- Thurlow JS, Joshi M, Yan G, Norris KC, Agodoa LY, Yuan CM. Global epidemiology of end-stage kidney disease and disparities in kidney replacement therapy. *Am J Nephrol*. 2021;52:98-107.
- Riset Kesehatan Dasar (Riskesmas). 2018. Badan Penelitian dan Pengembangan Kesehatan Kementerian Kesehatan RI. Available at: https://kesmas.kemkes.go.id/assets/upload/dir_519d41d8cd98f00/files/Hasil-riskesmas-2018_1274.pdf. Accessed on 09 March 2022.
- Vanholder RC, Ringoir SM. Adequacy of dialysis: a critical analysis. *Kidney Int*. 1992;42(3):540-58.
- Ansell D, Roderick P, Hodsman A, Ford D, Steenkamp R, Tomson C. UK Renal registry 11th annual report. *Nephron Clin Pract*. 2009;111(1):113-9.
- Hakim PRM. Assessing the adequacy of dialysis. *Kidney Int*. 1990;37(2):822-32.
- Hakim RM, Breyer J, Ismail N, Schulman G. Effects of dose dialysis on morbidity and mortality. *Am J Kidney Dis*. 1994;23(5):661-9.
- Suwitra K. Penyakit ginjal kronis. In: Sudoyo AW, Setiyohadi B, Alwi I, Simadibrata KM, Setiati S. *Buku Ajar Ilmu Penyakit Dalam*. 5th ed. Jakarta: FK UI; 2009: 1035-1040.
- Somji SS, Ruggajo P, Moledina S. Adequacy of hemodialysis and its associated factors among patients undergoing chronic hemodialysis in dar es salaam, Tanzania. *Int J Nephrol*. 2020;9863065.
- Dialysis Outcomes Quality Initiative (DOQI) Clinical practice guidelines and clinical practice recommendations updates for hemodialysis adequacy, 2006. Available at: https://www.kidney.org/sites/default/500210_jp_guidelin. Accessed on 09 March 2022.
- 11th Report of Indonesian Renal Registry. PERNEFRI, 2018. Available at: <https://www.indonesianrenalregistry.org/data/IRR%202018.pdf>. Accessed on 27 June 2022.
- KDIGO. Clinical practice guideline for the evaluation and management of chronic kidney disease. *Kid Int*. 2013;1(3):18-27.
- Baloglu I, Selcuk NY, Evran H, Tonbul HZ, Turkmen K. Evaluation of hemodialysis adequacy: correlation between Kt/Vurea and other methods. *Turk J Nephrol*. 2019;28(3):193-6.
- Widiana IGR. Preskripsi dan adekuasi hemodialisis. *Medicina Jurnal Ilmiah Kedokteran*. 2013;44(4).
- Rasul MM, Rahman AKMM, Anessa, Khan AS, Hussain T. Assesment of hemodialysis adequacy in patients with end stage renal disease in a military hospital of Dhaka, Bangladesh. *J Bangladesh Coll Phys Surg*. 2019;37(4).
- Anees M, Malik MR, Abbasi T, Nasir Z, Hussain Y, Ibrahim M. Demographic factors affecting quality of life of hemodialysis patients - Lahore, Pakistan. *Pak J Med Sci*. 2014;30(5):1123-7.
- Tayyebi A, Savari S, Nehrir B, Rahimi A, Eynollahi B. The effect of Vitamin B12 supplementation on fatigue in hemodialysis patients. *Iran J Crit Care Nurs*. 2013;6:39-48.
- Rezaiee O, Shahgholian N, Shahidi S. Assessment of hemodialysis adequacy and its relationship with individual and personal factors. *Iran J Nurs Midwifery Res*. 2016;21(6):577-82.
- Utami AS, Asmara IGY, Irawati D. Hubungan adekuasi hemodialisis dengan status gizi pasien penyakit ginjal kronis yang menjalani hemodialisis regular di RSUD Kota Mataram. *Jurnal Kedokteran Unram*. 2021;10(3):502-8.
- Nunes FT, Campos G, Paula SMX, Merhi VAL, Portero-McLellan KC, Motta DG et al. Dialysis adequacy and nutritional status of hemodialysis patients. *Hemodialysis Int*. 2008;12:45-51.
- Shariati AR, Asayesh H, Nasiri H, Tajbakhsh R, Hesam M, Mollaei E, et al. To compare dialysis adequacy in patient's that referred to Golestan province hemodialysis centers. *Health Inf Manag*. 2012;1:56-64.
- Roozitalab M, Moohamadi B, Najafi SH, Mehrabi S. Determining the adequacy of hemodialysis in hemodialysis units of Kohgiluyeh and Boyer-Ahmad hospitals in 2009. *Armaghane Danesh*. 2010;15:273-82.
- Daugirdas JT. Eliminating the need for routine monthly postdialysis serum urea nitrogen measurement: A method for monitoring Kt/V and

normalized protein catabolic rate using conductivity determined dialyzer clearance. *Semin Dial*. 2018;31(6):633-6.

23. Kim HW, Heo SJ, Kim JY, Kim A, Nam CM, Kim BS. Dialysis adequacy predictions using a machine learning method. *Scientific Reports*. 2021;11:15417.

Cite this article as: Sartika KD, Sunaka IW. Comparison of urea reduction ratio and dialysis efficacy in evaluating haemodialysis adequacy in chronic kidney disease patients in Wangaya Hospital. *Int J Adv Med* 2022;9:910-5.