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Original Article

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Evaluation of Hemodialysis Adequacy: Correlation between Kt/V_{urea} and Other Methods

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Abstract

Objective: Uremic toxins must be adequately cleared to reduce mortality and morbidity in chronic hemodialysis patients. The second-generation Daugirdas formula (D) is recommended for measurement of hemodialysis adequacy according to the guidelines specified by Kidney Disease Outcomes Quality Initiative (KDOQI) in guidelines. We aimed to compare the Kt/V ratio obtained by D (D Kt/V) to the urea reduction ratio (URR) and the Online Clearance Monitor (OCM®).
Materials and Methods: Our research is across-sectional study on 48 patients who are on maintenance hemodialysis (HD). A total of 1990 HD sessions were performed 3 times a week for 4 hours each day for 3 months. Ionic dialysate was measured by OCM module of the Fresenius 4008 C machine. In the same HD session, URR and Kt/V ratio were calculated using a single-pool Daugirdas formula.
Results: This study included 48 (Male: 24, Female: 24) adult chronic HD patients. Mean age of the patients was 54.5±18.1 years (16-81 years). Mean Kt/V value was found be higher when calculated using D formula (1.54±0.36) than what was measured by ionic dialysate (1.37±0.32) (p<0.0001). Comparison between D Kt/V and URR showed a statistically relevant significance (p<0.0001, r=0.92). Mean ultrafiltration (UF) was 1521±1054 milliliters per session. When D Kt/V was calculated without UF, the mean Kt/V value measured by ionic dialysate was not different from D Kt/V without considering UF (1.43±0.32) (p=0.101). In spite of the fact that URR was positively correlated with two formulas, the relationship between D Kt/V and URR was statistically more significant.
Conclusion: In our study, Kt/V calculated with D formula was higher than Kt/V measured by OCM. If the Daugirdas formula was calculated without considering UF, the Kt/V found by both methods was similar. Even though the URR correlated with two formulas, the relationship between D Kt/V and URR was statistically more significant. OMC is a practical tool that can help us to assess hemodialysis adequacy.
Keywords: Hemodialysis, Kt/V, online clearance monitor

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INTRODUCTION

Measurement of the dialysis dose is the most important factor in the management of chronic kidney disease patients who are on maintenance hemodialysis (HD). Many studies have shown that there is a significant correlation between the average delivered dialysis dose and patient mortality rates (1, 2). Various formulas such as urea reduction ratio (URR), Kt/V single pool (spKt/V), and equilibrated Kt/V (eKt/V), can be used to quantify the dose of dialysis. The basic principle in measuring dialysis efficacy is the comparison between the baseline and the final concentration of a defined substance in the blood of the patient. Urea is usually used to measure dialysis activity because it is representative of all uremic toxins and is an easily dialyzed solute.

The dose of hemodialysis is calculated with (K ureax Td)/Vurea (abbreviated as Kt/V). K urea is the effective (delivered) dialyzer urea clearance measured in milliliters per minute, which is integrated over the entire dialysis process and depends on dialyzer size, blood flow rate, and dialysate flow. Td is the time in minutes that is measured from the beginning to the end of dialysis and usually ranges from 3-4 hours (180-240 minutes per dialysis session). V urea is the patient's volume of urea distribution measured in liters and it corresponds to approximately 50% of body weight, although it may be more precisely estimated with appropriate formulas using parameters such as gender, age, height and weight (3, 4).

The most common model for calculating Kt/V is the single-pool variable (spKt/V) volume. In daily practice spKt/V may be computed according to the classic Daugirdas equation:

$$spKt/V=-\ln(R-0.008\times t)+(4-3.5\times R)\ 0.55\times UF/V$$

In this equation the symbols are represented as; R: predialysis urea/postdialysis urea, t: dialysis time in hours, -ln: negative natural logarithm, UF: weight loss in kilograms, and V: anthropometric urea distribution volume in liters (5).

URR, another method for measuring the dialysis dose, is calculated using the formula:

$$100 \times (1 - [C_t/C_o])$$

The values of this formula are; C_t: blood urea nitrogen measured 5 minutes after the end of dialysis and C_o: predialysis blood urea nitrogen (6). URR depends on the clearance of urea, the length of the dialysis treatment and the volume of urea distribution in a patient. An adequate level of URR is considered above 65%-70% because increased mortality has been shown when URR levels fall below 60% (7).

The alternative method for calculating Kt/V is based on measuring the difference between the conductivity of the dialysis fluid entering and leaving the dialyzer and the difference in electrolyte concentration of these fluids (8). Sodium ions represent the largest proportion of electrolytes in the dialysis fluid and their concentration essentially determines the total conductivity of the dialysis fluid. Although the sodium ion differs from the urea molecule, both particles exhibit comparable in-vitro and *in-vivo* diffusion characteristics across a synthetic dialysis membrane (9). Thus, urea clearance can be determined by calculating the ionic clearance of sodium (10). In this method, dialysis machines provide online real-time monitoring of dialysis efficiency, by showing the measured Kt/V on the screen. Additionally, this method is noninvasive, easy to perform, and cost-effective.

According to Kidney Disease Outcomes Quality Initiative guidelines (KDOQI), the approved method for Kt/V calculation is by the Daugirdas formula, and KDOQI guidelines recommend that spKt/V should be kept above 1.2 (11).

In this study, we aimed to compare the Kt/V ratio obtained using the Daugirdas formula (DKt/V) with the Kt/V results measured by an Online Clearance Monitor (OCM®).

MATERIALS AND METHODS

The study protocol was approved by the Medical Ethics Committee of Necmettin Erbakan University (School of Medicine, Konya, Turkey). Written informed consent was obtained from the patients.

This was a cross-sectional study involving 48 End-stage renal disease ESRD patients (24 females and24 males; mean age: 54.5±18.1years) who had been receiving HD for ≥6 months in the Hemodialysis Unit of Necmettin Erbakan University Meram School of Medicine, Konya, Turkey.

The demographic data, the primary cause of ESRD, duration of dialysis, and comorbidities, if any, were recorded. Dry weight, weight gain between sessions, height, age, sex, blood flow, and hematocrit values of the patients were also collected for calculating Kt/V.

Kt/V was measured by three different techniques. The first method was the common method using sampling of blood and calculation by Daugirdas formula. Two blood samples were taken from each patient before and after dialysis. According to the method previously described, Kt/V urea was calculated by the second-generation Daugirdas formula:

$$(spKt/V=-\ln(R-0.008\times t)+(4-3.5\times R)\ 0.55\times UF/V)$$

In the second technique, the URR was calculated. In the third technique, Kt/V was calculated automatically using Fresenius 4008 C dialysis machines by online clearance monitoring based on the difference of plasma conductivity.

Hemodialysis modality included conventional 4-hour HD sessions 3times a week with polysulfone dialyzers. A mean blood flow rate of 250 mL/min (range: 200-300 mL/min) was obtained during the dialysis sessions and the standard dialysate flow in all machines was 500 ml/min. Dialysate fluid composition included 128-143mEq/L of sodium, 1-4 mEq/L of potassium, 3 mEq/L of calcium, 1.8 mEq/L of magnesium, and 33 mEq/L of bicarbonate.

Statistical Analysis

The study protocol was approved by the Medical Ethics Committee of Necmettin Erbakan University (School of Medicine, Konya, Turkey). Written informed consent was obtained from patients.

The values were expressed as the mean±standard deviation. The D'Agostino-Pearson test was used for normal distribution and the groups were compared with the independent samples t-test. The correlations between groups were evaluated by the Spearman test. The Statistical Package for the Social Sciences program was used for statistical calculations.

RESULTS

In this study, a total of 1990 HD sessions were performed 3 times a week in 4-hour sessions eachfor3 months. Demographic and

Table 1. Demographic and clinic features of the study group

Age	54.5±18.1 years
Sex: Male/Female	24/24
Etiology of kidney disease	
Diabetes Mellitus	15
Chronic interstitial nephritis	8
Polycystic kidney disease	5
Chronic glomerulonephritis	3
Ischemic kidney disease	3
Unknown	14
Comorbidities	
Hypertension	15
Coronary artery disease	9
Heart failure	5
Cerebrovascular disease	6
Multiple sclerosis	1

Table 2. Comparison of methods

Method	N	Mean	
Daugirdas formula	48	1.54±0.36	p<0.0001
URR	48	74.3±8.06	r=0.92
OCM	48	1.37±0.32	p=0.101
Daugirdas formula without UF	48	1.43±0.32	r=0.77

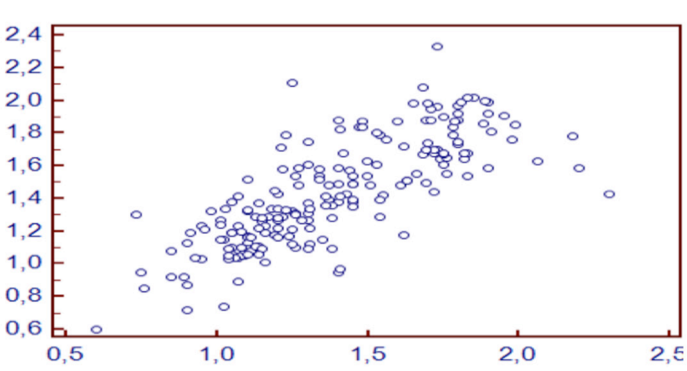

Figure 1. Comparison of two methods. .x axis is the Kt/V values calculated by D without UF and y axis is the Kt/V values calculated by OCM. r=0.77; Confidence interval (95%) for r: 0.71-0.82; p<0.0001.

clinical characteristics of the patients are depicted in Table 1. Mean dialysate sodium value was 136.3±2.07 and mean sodium value of the patients was 137±2.96. Mean Kt/V value calculated by D, OCM, and D without UF was found to be 1.54±0.36, 1.37±0.32 and 1.43±0.32 respectively. Mean URR was calculated as 74.3±8.06. When D and OCM were compared, the mean Kt/V value was significantly higher with D formula (t=−4.69, p<0.0001). Comparison between D Kt/V and URR showed a statistically significant positive correlation (p<0.0001, r=0.92). There was also a significant correlation seen between URR and OCM Kt/V (p<0.0001, r=0.735). In spite of the fact that URR was associated with two other formulas, the relationship between D and URR had a higher r value.

In our study, the mean ultrafiltration (UF) was 1521±1054 milliliters per session. The mean Kt/V value, measured by both, ionic dialysance and D without UF was not different (p=0.101). There was a significant correlation seen between both methods (r=0.77) (Table 2) (Figure 1).

DISCUSSION

The main findings of this cross-sectional study were; first, the Kt/V value measured by ionic dialysance and by Daugirdas formula without ultrafiltration was significantly similar in HD patients and second, the relationship between D and URR was statistically more significant.

When compared with the normal population, mortality is higher in hemodialysis patients (12). One of the factors affecting patient mortality is hemodialysis adequacy. Several studies have shown that an adequate hemodialysis dose was associated with reduced mortality (13). Adequate hemodialysis dose is assessed by measuring Kt/V and it is recommended that Kt/V, which can be measured by different formulas, should be kept above 1.2 (11-14).

In a study performed by Breitsameter et al., Kt/V ratios were determined by different formulas in 159 patients, where they found that the mean Kt/V measured by OCM was lower than the Kt/V calculated by Daugirdas formula (15). In another study, Sabry et al. found that there was a significant difference between mean D Kt/V and OCM Kt/V values (16). Similarly, in our study, the mean Kt/V value was significantly higher with Daugirdas formula (1.54±0.36) than what was measured by ionic dialysance (1.37±0.32) (p<0.0001).

Measurement using ionic dialysance is a faster, less expensive, and noninvasive method. But in this method, the estimated V is usually greater when calculated by the patient parameters of weight, height, age, and gender. Therefore, Kt/V measured by OCM is generally lower than Kt/V calculated by D (17). In addition, Kt/V calculated by online clearance is not necessarily automatically corrected for a rebound, though this could easily be done by the equipment. In our study, when we calculated Kt/V byD without UF, OCM Kt/V and D Kt/V were similar.

Our study had some limitations, which were; first, all of the patients who were enrolled in the study were of Turkish ethnicity, so these results may not be applicable to other races, and second, our study was designed as a single-center design and the sample size was relatively small.

CONCLUSION

We found a statistically significant difference between the results obtained with the Daugirdas formula and those obtained using the OCM. However, when Kt/V was calculated by D without UF, the difference between the formulas was nullified. URR was positively correlated with two formulas, but the relationship between D and URR was statistically more significant. Therefore, the OCM can be used as a practical tool that can help other formulas to demonstrate hemodialysis efficiency, especially without UF. Additionally, online clearance should not be used as a reference method for monthly measurements.

Ethics Committee Approval: The study protocol was approved by the Medical Ethics Committee of Necmettin Erbakan University School of Medicine, Konya, Turkey.

Informed Consent: Written informed consent was obtained from patients.

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