Evaluation of Hemodialysis Adequacy: Correlation between $\frac{K_t}{V}$ 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 $\frac{K_t}{V}$ ratio obtained by D (D $\frac{K_t}{V}$) 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 $\frac{K_t}{V}$ 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 $\frac{K_t}{V}$ 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 $\frac{K_t}{V}$ and URR showed a statistically relevant significance ($p=0.0001$, $r=0.92$). Mean ultrafiltration (UF) was 1521±1054 milliliters per session. When D $\frac{K_t}{V}$ was calculated without UF, the mean $\frac{K_t}{V}$ value measured by ionic dialysate was not different from D $\frac{K_t}{V}$ 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 $\frac{K_t}{V}$ and URR was statistically more significant.

Conclusion: In our study, $\frac{K_t}{V}$ calculated with D formula was higher than $\frac{K_t}{V}$ measured by OCM. If the Daugirdas formula was calculated without considering UF, the $\frac{K_t}{V}$ found by both methods was similar. Even though the URR correlated with two formulas, the relationship between D $\frac{K_t}{V}$ and URR was statistically more significant. OMC is a practical tool that can help us to assess hemodialysis adequacy.

Keywords: Hemodialysis, $\frac{K_t}{V}$, online clearance monitor

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), $\frac{K_t}{V}$ single pool (sp$\frac{K_t}{V}$), and equilibrated $\frac{K_t}{V}$ (e$\frac{K_t}{V}$), 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 $(K_{urea} T_d)/V_{urea}$ (abbreviated as $\frac{K_t}{V}$). $K_{urea}$ is the effective (delivered) dialyzer urea clearance measured in milliliters per minute, which is integrated over the entire dialysis
In this study, we aimed to compare the $Kt/V$ ratio obtained using the Daugirdas formula ($DKt/V$) with the $Kt/V$ results measured 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.

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

$$100 \times \left(1 - \frac{C_t}{C_0}\right)$$

The values of this formula are; $C_t$: blood urea nitrogen measured 5 minutes after the end of dialysis and $C_0$: predialysis blood urea nitrogen. $URR$ 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%.

The alternative method for calculating $Kt/V$ is based on measuring the difference between the conductivity of the dialysate fluid entering and leaving the dialyzer and the difference in electrolyte concentration of these fluids. 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. Thus, urea clearance can be determined by calculating the ionic clearance of sodium. 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.

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®).
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 by D 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.

Peer-review: Externally peer-reviewed.


Conflict of Interest: The authors have no conflict of interest to declare.

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