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## Comparative Analysis of Hemodialysis Adequacy: A Study on OCM vs. Daugirdas Formula

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### Abstract

**Introduction:** The precise assessment of hemodialysis adequacy is crucial for determining the clinical prognosis of individuals undergoing chronic hemodialysis. This study investigates the relationship between online clearance monitoring (OCM) and routine monitoring of Kt/V, utilizing the Daugirdas Formula as a benchmark.

**Methods:** The research, conducted on 190 patients with end-stage renal illness undergoing hemodialysis, employed observational methods and excluded critically ill patients and those with non-adherence to prescribed dialysis regimens. The study aimed to assess hemodialysis adequacy by comparing Kt/V values calculated using the Daugirdas formula, OCM, and the urea reduction ratio. Hemodialysis procedures, conducted using Fresenius 4008S equipment, included two blood samplings per patient at the beginning and end of each session. Samples were analyzed for serum Urea, Creatinine, Bicarbonate, Sodium, and Potassium levels.

**Results:** Statistical analysis revealed a lack of significant difference between Kt/V values obtained from the Daugirdas formula and OCM. Results from 190 patients, with an average age of  $50.08 \pm 12.33$  years, demonstrated that the Daugirdas formula and OCM did not significantly differ (P Value=0.175, r 0.169).

**Conclusion:** The study acknowledges limitations such as its single-centre design, limited sample size, and the exclusive representation of Asian ethnicity among participants, the findings offer valuable insights into hemodialysis adequacy assessment. These insights contribute to the ongoing dialogue in the field and provide guidance for clinicians in optimizing dialysis protocols to enhance patient outcomes. The study underscores the need for future research with more diverse cohorts to further validate and extend the applicability of the observed relationships.

**Keywords:** Hemodialysis Adequacy Assessment, Online Clearance Monitoring (OCM)

Daugirdas Formula, Renal Illness Management, Clinical Prognosis

### Introduction

The precise administration of hemodialysis dose is essential for optimizing the clinical outcomes of individuals undergoing chronic hemodialysis<sup>1</sup>. Hemodialysis adequacy is

traditionally assessed through two primary measures: the Kt/V (dialysis dose) and urea reduction ratio (URR). Kt/V is a dimensionless value that quantifies dialysis adequacy by combining the clearance rate of urea (K), the duration of dialysis (t), and the volume of distribution of urea (V). It is calculated as  $Kt/V = K \times t / V$ , where K is the clearance of urea by the dialyzer, t is the treatment time, and V is the volume of distribution of urea, typically approximated as the patient's total body water. A Kt/V value of 1.4 per session is recommended by the Kidney Disease: Improving Global Outcomes (KDIGO) guidelines to ensure adequate dialysis. Achieving this target has been linked with improved clinical outcomes, including reduced mortality rates and better cardiovascular health in dialysis patients.<sup>2</sup>

Various methods exist to estimate Kt/V, with the Daugirdas formula, online clearance monitoring (OCM), and normogram-based calculations being the most commonly utilized.<sup>3</sup> The Daugirdas formula, a well-established method, calculates Kt/V based on the urea reduction ratio (URR) and is widely used in clinical settings. This method is particularly helpful for its simplicity but comes with limitations, particularly in its reliance on several assumptions about urea distribution and clearance, which may not always be accurate for every patient. For example, the formula assumes a constant volume of distribution, which may not reflect fluctuations in patient conditions.<sup>3,4</sup>

In contrast, online clearance monitoring (OCM) provides a non-invasive method for assessing Kt/V during hemodialysis. OCM technology involves the real-time measurement of the conductivity difference between the dialysate entering and exiting the dialyzer, using two distinct dialysate electrolyte concentration monitors. This method allows continuous monitoring of dialysis efficiency throughout the session and provides immediate feedback on the dialysis process. Unlike traditional methods that require blood samples to measure urea levels, OCM offers a real-time, non-invasive alternative that potentially reduces patient discomfort and allows for immediate adjustments in dialysis treatment. The real-time data provided by OCM could potentially offer more accurate and timely assessments of dialysis adequacy compared to the Daugirdas formula, which is reliant on periodic blood sampling.<sup>4</sup>

This study aims to evaluate the effectiveness and reliability of OCM in the context of routine hemodialysis monitoring, particularly in assessing Kt/V. The research will compare the performance of OCM to traditional methods such as the Daugirdas formula and urea reduction ratio (URR), with a specific focus on understanding the strengths and weaknesses of each approach. By evaluating the accuracy, efficiency, and clinical relevance of these methods, the

study seeks to determine whether OCM could serve as a more reliable tool for assessing hemodialysis adequacy in routine clinical practice. Furthermore, the research will investigate the potential benefits of using OCM to enhance patient outcomes by improving dialysis dose adjustments in real time and reducing reliance on invasive blood sampling.

The ultimate goal of this research is to contribute valuable insights to the growing body of knowledge surrounding hemodialysis monitoring. By examining the comparative effectiveness of OCM against traditional methodologies, the study aims to advance clinical practices and improve patient care. Understanding the best methods to assess dialysis adequacy is crucial for optimizing treatment protocols and improving the overall well-being of individuals undergoing chronic hemodialysis. With a focus on enhancing accuracy, efficiency, and patient outcomes, this study has the potential to guide clinicians in refining dialysis management strategies and providing the best possible care to their patients.

### **Material and Method**

This study was conducted using observational methods. The study included a sample of 190 patients with end stage renal illness who were undergoing hemodialysis. The participants were selected via convenience non-probability sampling. Prior to the commencement of the study, informed consent was obtained from all participants. Patients who were critically ill and had several co-morbidities, such as sepsis (defined as a total leukocyte count greater than 11000 or less than 4000 x 10<sup>9</sup>/L), ischemic heart disease, pacemakers, malignancies, cirrhosis, and so on, were not included in the study. Patients who demonstrated non-adherence to the prescribed dialysis regimen or exhibited hemodynamic instability were also excluded from the study.

The hemodialysis procedures were conducted using Fresenius 4008S hemodialysis equipment equipped with a dialyzer of 1.8 m<sup>2</sup>. The duration of each dialysis treatment ranged from four to five hours. This cross-sectional study aimed to assess the adequacy of hemodialysis in the enrolled patients. This was achieved by comparing the calculated Kt/V using the Daugirdas formula, the online clearance monitor, and the urea reduction ratio.

Every subject had two blood samplings. The initial sample was collected at the commencement of the hemodialysis session, while the subsequent sample was obtained at the conclusion of the same session after adjusting the ultrafiltration rate to zero. This was achieved by decreasing the blood pump flow to a level below 100 ml/min for a duration of 10-20 seconds, followed by complete cessation of pump flow.

At this juncture, a blood sample was acquired from the arterial blood line sampling port. Subsequently, both of these appropriately labeled samples were dispatched to the pathology laboratory for the purpose of quantifying the levels of serum Urea, Creatinine, Bicarbonate, Sodium, and Potassium. The present study obtained ethical approval from Hasanuddin university, Indonesia, under the assigned ethical number UH23080633.

**Kt/V Formula.** The formula utilized for the quantification of manual measurement was employed. The Kt/V value is a measure used in the field of nephrology to assess the adequacy of dialysis treatment. It is calculated using the Daugird The equation  $Kt/V_{sp} = -\ln(R - 0.008 \times t) + (4 - 3.5 \times R) \times U_f/W$  represents a mathematical relationship. In this equation,  $\ln$  refers to the natural logarithm,  $R$  represents the ratio of postdialytic divided by predialytic BUN (blood urea nitrogen) levels,  $t$  represents the effective dialysis time in hours,  $U_f$  represents the ultrafiltration volume in litres, and  $W$  represents the weight of the patient after dialysis in kilograms. The topic of discussion is the single pool Kt/V, specifically denoted as Kt/V<sub>sp</sub>.

**Statistical analysis.** The data was inputted and analyzed using IBM SPSS version 20.0. The mean and standard deviation (SD) were computed for quantitative variables such as age, Kt/V, and duration of dialysis. Frequency and percentages were computed for qualitative data, specifically gender. The Pearson correlation coefficient was employed to determine the correlation between the Daugirdas formula and OCM. A  $p$ -value less than or equal to 0.05 is considered statistically significant.

## Results

All patients had an average age of  $50.08 \pm 12.33$  years. 90 cases (47.6% male and 83 cases (43.9%) female. The average HD frequency was  $2.1 \pm 0.9$  times per week, and the average HD duration was  $1.2 \pm 2.0$  years. The ultrafiltration session mean was  $1.4 \pm 0.76$  litres. The dialysis flow rate was  $541 \pm 441.8$  ml/min and the blood flow rate were  $168.9 \pm 22.3$  ml/min for each patient. The Dougirdas formula yielded mean Kt/V values of  $1.33 \pm 0.76$  and mean OCM values of  $1.74 \pm 1.92$ . (Table 1)

*Table 1 Data Characteristic*

	Mean
Age	$50.08 \pm 12.33$
Hemodialysis duration	$4.54 \pm 0.59$
Time dialysis	$1.26 \pm 2.02$
Hemodialysis frequency	$2.19 \pm 0.91$
Ultrafiltration goal	$1423 \pm 706$
Qb	$168.9 \pm 22.3$
OCM values	$1.74 \pm 1.92$

Kt/V values	1.33±0.76
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Based on correlation analysis, the Daugirdas formula and OCM by Pearson did not differ significantly (P Value=0.175, r 0.169) (Table 2).

Table 2 Correlation between Kt/V values measured with OCM

	Correlation coefficient (r) Dargirdas Formula	pValue Pearson's correlation
OCM	0,169	0,175

## Discussion

Hemodialysis (HD) is a crucial life-saving treatment for patients with end-stage renal disease (ESRD). One of the key aspects of managing these patients is ensuring that the dialysis procedure is adequate in clearing toxins and maintaining fluid balance. The viability of individuals with end-stage kidney disease (ESKD) is facilitated through the elimination of uremic solutes with dialysis. The quantity of dialysis administered to a patient and the extent of uremic toxin elimination can have an impact on morbidity and mortality rates <sup>5</sup>.

Two primary concerns in the treatment of patients undergoing maintenance hemodialysis are the determination of the most advantageous dosage of dialysis to be recommended and the quantification of the actual dosage of dialysis administered to specific patients <sup>6</sup>. Adequacy of hemodialysis is traditionally evaluated using various markers, of which the Kt/V (calculated by the Daugirdas formula) and OCM (Observed Clearance of Urea) are two widely used metrics. The current methodologies employed for quantifying dialysis dosage rely on the assessment of urea clearance. The assessment of an appropriate hemodialysis dose is conducted through the measurement of Kt/V. It is advised that Kt/V, which may be determined using several formulas, should be maintained at a level higher than 1.4 <sup>7</sup>.

The cross-sectional in this study had a mean age of 50.08 ± 12.33 years, suggesting a predominantly middle-aged population. This age group is significant because age plays an important role in the overall prognosis of ESRD patients, with older individuals often exhibiting more comorbidities, decreased tolerance to dialysis, and increased risk of complications such as cardiovascular events. The age distribution in this study suggests that the sample may represent patients at varying stages of chronic kidney disease, with treatment

intensities adjusted to individual needs. Furthermore, the gender distribution, with 47.6% male and 43.9% female patients, reflects a reasonably balanced representation of the population, although differences in dialysis outcomes between sexes have been reported in literature. Some studies suggest that men may experience poorer dialysis outcomes, possibly due to differences in body composition, hypertension, and cardiovascular risk factors, all of which are common in ESRD patients.<sup>8</sup>

In terms of dialysis specifics, the average hemodialysis frequency was  $2.1 \pm 0.9$  times per week, a figure consistent with the guidelines for maintenance dialysis, which typically recommends 2 to 3 sessions per week. The dialysis duration of  $1.2 \pm 2.0$  years suggests that many patients in this study were in the chronic stage of kidney disease, requiring long-term hemodialysis therapy. Long-term dialysis patients may have unique challenges, including dialysis-related amyloidosis, catheter-related infections, and vascular access complications, which are often compounded by comorbid conditions like diabetes or cardiovascular disease.

Additional dialysis parameters such as ultrafiltration rate ( $1.4 \pm 0.76$  liters), dialysis flow rate ( $541 \pm 441.8$  ml/min), and blood flow rate ( $168.9 \pm 22.3$  ml/min) provide further details on the procedural aspect of dialysis. The ultrafiltration rate, crucial for fluid removal, aligns with typical clinical standards, as excessive fluid removal can lead to hypotension or other complications. The dialysis and blood flow rates, indicative of the machine's efficiency at filtering toxins from the blood, are also within expected ranges, suggesting effective dialysis in this study.

Adequate dialysis is essential for preventing uremic toxicity, maintaining electrolyte balance, and ensuring fluid control. The most commonly used measure to evaluate dialysis adequacy is Kt/V, where K represents the dialyzer clearance of urea, t is time, and V is the volume of distribution of urea. The Daugirdas formula is typically used to calculate Kt/V, and it has long been considered the gold standard for assessing dialysis adequacy. The mean Kt/V value in this study was  $1.33 \pm 0.76$ , which is generally considered an acceptable level of dialysis, as a Kt/V of at least 1.2 is recommended for most patients on hemodialysis. However, it is important to note that Kt/V, while valuable, only indirectly measures the effectiveness of dialysis, focusing primarily on urea clearance, which may not fully capture the removal of other solutes that contribute to uremic symptoms.

OCM (Observed Clearance of Urea), on the other hand, is a relatively newer method for evaluating dialysis adequacy. It reflects the total observed clearance of urea over the course of

a dialysis session, taking into account the patient's pre- and post-dialysis urea levels. OCM is considered a direct measure of the efficacy of the dialysis treatment in removing waste products. In the study, the mean OCM value was  $1.74 \pm 1.92$ , which suggests an overall clearance that aligns with acceptable dialysis efficiency. However, OCM has not been universally adopted in clinical practice, as it requires more direct measurement of urea clearance and may be less practical in routine clinical settings compared to Kt/V, which can be easily calculated with the Daugirdas formula.

The primary results of this cross-sectional investigation indicate a lack of substantial link between the Kt/V manual value and the Kt/V OCM. This study found that both measures yielded similar results with a Pearson correlation coefficient of  $r = 0.169$  and a p-value of 0.175. This suggests that there is no significant statistical difference between the two measures in this cohort of patients, meaning that both Kt/V and OCM provide comparable information regarding the adequacy of dialysis in this particular group.

The lack of significant difference between the two methods has several clinical implications. First, it indicates that OCM, which is a more direct measure of urea clearance during dialysis, might be a viable alternative to the Daugirdas formula for assessing dialysis adequacy. This could be particularly useful in clinical settings where there are concerns about the accuracy or accessibility of Kt/V measurements, or in situations where the patient's individual characteristics (such as low blood pressure or an unstable clinical condition) might make Kt/V less reliable. Additionally, the non-significant difference supports the notion that both Kt/V and OCM are capable of guiding clinical decisions, including adjustments in dialysis prescriptions (e.g., frequency, duration, or blood flow rate) to optimize treatment outcomes. However, it is commonly observed that the predicted V tends to be higher when computed using patient-specific characteristics such as weight, height, age, and gender. Furthermore, it should be noted that the Kt/V value obtained by online clearance calculations may not be automatically adjusted for a rebound effect. However, it is worth mentioning that the equipment has the capability to simply incorporate such corrections<sup>9,10</sup>.

Baloglu et al. reported that the Kt/V value estimated using the D formula was found to be greater than the Kt/V value observed by OCM. When the Daugirdas formula was computed without taking into account ultrafiltration (UF), the resulting Kt/V values obtained from both approaches exhibited a high degree of similarity<sup>11</sup>. Kt/V OCM was also suggested by Mateen et al. and Sujit et al. as a useful tool to supplement other formulas in clinical practice<sup>12,13</sup>.

However, while these findings are significant, there are limitations to consider. First, the study's sample size, as indicated by the average and standard deviation figures, may not be large enough to extrapolate these results to all ESRD patients. Secondly, the study only focused on the clearance of urea, but there are other important solutes (such as phosphate, potassium, and  $\beta$ 2-microglobulin) that also play a role in the overall clinical condition of patients undergoing hemodialysis. Further research is needed to evaluate how Kt/V and OCM compare in terms of their ability to clear a broader range of solutes.

### **Conclusion**

The crucial function of dialysis in end-stage kidney disease is underscored, where the dosage of dialysis plays a significant role in affecting morbidity and mortality rates. Nevertheless, the research suggests a restricted association between manually calculated Kt/V and Kt/V OCM, emphasizing the potential of the latter as an economical and noninvasive method, even though factors specific to individual patients should be taken into account. The study, however, recognizes constraints such as a single-centre design and a limited sample size, mainly consisting of Asian participants, urging caution in making broad generalizations based on these findings.

### **Authorship**

Hasyim Kasim\*: Conceptualization, data collection, writing, funding acquisition. Khadijah Khairunnisa Hasyim: data collection, methodology. Haerani Rasyid: methodology, writing. Nasrum Machmud: Data modelling. Andi Alfian Zainuddin: writing - review & editing.

### **Conflict of interest**

The authors declare no conflict of interest.

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