

Comparison of Kt/V in Haemodialysis By Daugirdas Method And By Online Clearance Monitoring

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Abstract

Introduction: The measurement of the dialysis dose is a vital element in the management of chronic kidney disease patients on maintenance haemodialysis (HD). The dose of haemodialysis is expressed as $(K \text{ urea} \times Td)/V_{\text{urea}}$ (abbreviated as Kt/V). Single-pool variable volume spKt/V is the most widely used at present is the following formula for calculating Kt/V.

Aim: To compare the Kt/V ratio obtained with the Daugirdas formula (D) with the results measured by an Online Clearance Monitor (OCM).

Materials and methods: Our study is a cross sectional study of 50 patients on maintenance hemodialysis. Patients dry weight, weight gain between sessions, height, age, sex, blood flow, hematocrit, pre and post blood urea nitrogen were obtained for calculating Kt/V by Daugirdas formula (D). Kt/V results were obtained from the same Fresenius 4008S HD machine equipped with an OCM on the same dialysis session.

Results: 50 patients were studied. Out of which 33 were male patients (66%). Mean age of our study patients were 38.74 ± 11.18 years. The duration of hemodialysis didn't have any statistical significance with Kt/V measured by Kt/V (D) and Kt/V(OCM) by anova test. Independent sample t test showed that delivered Kt/V by brachio cephalic fistula was higher than radio cephalic fistula and p value was 0.01. The Kt/V (D) measured by daugirdas formulae was 1.53 ± 0.22 . The Kt/V(OCM) measured by online Clearance Monitor was 1.51 ± 0.21 . Intra class correlation coefficient showed a strong agreement between both methods, $r = 0.964$.

Conclusions: In our study, there is good correlation between Kt/V (D) and Kt/V (OCM). Online Clearance Monitor is a practical instrument for daily use, to complement the other formulas, helping to adequate the dialysis dose delivered to reach excellent patient's benefit.

I. Introduction

The measurement of the dialysis dose is a vital element in the management of chronic kidney disease patients on maintenance haemodialysis. A significant correlation between the average delivered dialysis dose and patient mortality rates has been demonstrated in many clinical studies^{1,2}. The adequacy of the dialysis dose has a profound effect on patient morbidity and mortality. All these studies emphasize that the higher the delivered dose of dialysis, lower the patient mortality rates. The National Cooperative Dialysis Study (NCDS) study was the first long term study which investigated the correlation between dialysis dose and therapeutic outcome³. These results have demonstrated a statistically significant relationship between urea elimination and mortality. The dialysis dose is defined as the quantity of dialysis treatment delivered for a given period of time. In general the dialysis dose is measured by the comparison between the baseline and final concentration of a defined substance in the blood of the patient. The more efficient the dialysis session, the greater is the reduction of this given substance. As urea is representative of all uremic toxins, easily dialysed solute, changes in urea concentration are monitored to calculate the dose of dialysis delivered. The dose of HD is expressed as $(K \text{ urea} \times Td)/V_{\text{urea}}$ (abbreviated as Kt/V), where K urea is the effective (delivered) dialyzer urea clearance in milliliters per minute integrated over the entire dialysis, Td is the time in minutes measured from beginning to end of dialysis, and V urea is the patient's volume of urea distribution in milliliters⁴.

Single-pool variable volume Kt/V is the most widely used for calculating Kt/V. This mathematical model uses the natural logarithm to calculate Kt/V, provides sufficiently accurate results over the full range of standard Kt/V values^{5,6}. In daily clinical practice spKt/V may be computed according to the classic Daugirdas equation, which is based on urea reduction ratio (URR) and accounts for intradialytic urea generation and ultrafiltration volume⁷. The Dialysis Outcomes Quality Initiative (DOQI)-approved method for Kt/V calculation is the Daugirdas's formula (1996): $\text{spKt/V} = -\ln(R - 0.008 \times t) + (4 - 3.5 \times R) \times 0.55 \times \text{UF/V}$, in which R is predialysis urea/postdialysis urea, t is dialysis time in hours, -ln is the negative natural logarithm, UF is ultrafiltration volume in litres and V is the anthropometric urea distribution volume in liters, which may be calculated with Watson's equation or simply estimated as $0.55 \times \text{postdialysis weight}$. This Daugirdas equation is validated for a Kt/V range of 0.8 to 2.0 and is widely used because of its simplicity and accuracy.

The other alternative methods for determining dialysis dose include measurements based on conductivity⁸ or of urea⁹ and recently ultraviolet absorbance in the spent dialysate. The dose of the dialysis can be assessed more frequently by measuring conductivity (online) clearance across the dialyzer membrane, which forms the basis for online clearance monitoring. This method is based on the assumption that changes in dialysate conductivity are caused by transmembrane movement of small electrolytes, mostly sodium which behaves like urea. Sodium ions represent the largest proportion of freely mobile electrolytes in the dialysis fluid and their concentration essentially determines the total conductivity of the dialysis fluid.

Although the small positively-charged sodium ion differs from the non-charged and larger urea molecule, both particles exhibit comparable in-vitro and in-vivo diffusion characteristics across a synthetic dialysis membrane, i. e. their specific diffusion coefficient is almost identical at 37°C (Na⁺: 1.94×10^{-5} cm²/s, Urea: 2.20×10^{-5} cm²/s)¹¹. By means of indirect determination of ion concentrations in the haemodialysis solution (measurement of conductivity at the inflow and outflow of the dialyser) it is technically possible to determine the diffusion profile of sodium ions across the dialysis membrane and thus calculate the dialysance or ionic clearance (D). On the basis of the dialysance of sodium ions, the “diffusibility” of urea through the membrane (permeability) and thus urea clearance can be determined¹².

II. Aim

To compare the Kt/V ratio obtained with the Daugirdas formula (D) with the results measured by an Online Clearance Monitor (OCM).

Inclusion criteria:

Chronic kidney disease stage 5 (CKD 5) patients on maintenance hemodialysis undergoing three sessions per week at our hemodialysis unit. All patients were undergoing hemodialysis through A.V. Fistula with blood flow of 250-280ml/min were included in study.

Exclusion criteria:

Patients under 18 years of age, patients with access dysfunction and patients on continuous ambulatory peritoneal dialysis.

III. Materials And Methods

Our study is a cross sectional study of 50 patients on maintenance hemodialysis (HD). Patients dry weight, weight gain between sessions, height, age, sex, blood flow, hematocrit were calculated for calculating Kt/V. Kt/V results obtained from the same Fresenius 4008S HD –new generation machine equipped with an online clearance monitoring (OCM) on the same dialysis session. The standard dialysate flow in all machines was 500 ml/min.

Measurement of dialysis adequacy

Kt/V was measured by two techniques. The first method is the conventional method with blood sampling and calculation by Daugirdas formula (Kt/V-D). Each patient underwent two blood samplings for calculation Kt/V (D). Pre dialysis sample for blood urea nitrogen was obtained by withdrawing 2 ml of blood sample for blood urea nitrogen from the arterial line of the extracorporeal system sample just prior to connecting the arterial blood tubing. After the prescribed dialysis time was completed, the dialysate flow was turned off, ultrafiltration (UF) rate was set zero, the blood pump was slowed down to 100 mL per minute for 15 seconds followed by stopping the blood pump. Then, post dialysis sample blood urea nitrogen was obtained by taking 2 ml of blood sample from the arterial blood line sampling port. The second technique is based on the effective plasma conductivity that is performed by two mutually independent temperature compensated conductivity cells equipped with Fresenius 4008 S® dialysis machines (Kt/V-OCM).

The Fresenius module changes the inlet conductivity every 30 min and records the change in conductivity at a second conductance measured the dialysate waste. From this change ionic dialysance and plasma conductivity can be calculated automatically. For each patient and each dialytic session, Kt/V by online clearance monitoring Kt/V-OCM is calculated automatically by the dialysis monitor. Total body water which is assumed to be equal to urea distribution volume was calculated by the dialysis machine using the empirical formula of Watson et al.¹³ for women and men, respectively.

IV. Statistical analysis

The values of Kt/V by both methods were expressed as mean ± standard deviation. A p value of < 0.05 was considered as statistical significant. The Anova method was used to measure the statistical significance between duration of hemodialysis and Kt/V. The Independent sample t test was used to measure the statistical significance of fistula access and Kt/V. The Intra class coefficient test was used to compare the

results obtained by both methods. The Statistical Package for the Social Sciences version 20 (SPSS) program was used for the statistical calculations.

V. Results

Patients:

We prospectively studied 50 patients . Out of which 33 were male patients (66%). Mean age of our study patients were 38.74 ± 11.18 . All patients were on thrice weekly hemodialysis for more than 2 months.

Table 1: showing the demographic variables of our 50 patients:

Age in years(mean)	38.74
Sex :Male / female	37/13
Native kidney disease	
Diabetes mellitus	24
Hypertension	11
Glomerulonephritis	9
Interstitial renal disease	2
Autosomal dominant polycystic disease	1
Not known	7
Co morbidities	
Diabetes mellitus	24
Hypertension	12
Cerebrovascular disease	8
Weight(kg)	55.74

Dialysis prescription:

All our patients were dialysed using Fresenius polysulphone Capillary dialysers F 6 . Patients received dialysis with Fresenius 4008 S monitors equipped with OCM biosensors (On-line clearance monitoring, Fresenius Medical Care AG). The treatment time for all patients was 4 hours . The blood flow varied between 250-280ml/minute the dialysate flow was fixed at 500ml/ minute. No changes were made to any of the dialysis prescriptions over the study period.

Majority of the patients were dialysed within first three months(52%)of the study. By using the Anova method, there is no statistical significance between duration of hemodialysis andKt/vcalculatedby both methods. The p value for Kt/V-D was 0.453 and for Kt/V-OCM was 0.440.Majority of the patients were dialysed using brachicephalic fistula 26 patients (52%) and 24 patients were dialysed using radiocephalic fistula(48%). By using the independent sample t test, type of fistula had statistical significance for kt/v by both methods. The p value for Kt/V-D was 0.01 and for Kt/V-OCM was 0.009.The Kt/V (D) measured by daugirdas formulae was 1.53 ± 0.22 . The Kt/V(OCM) measured by online Clearance Monitor was 1.51 ± 0.21 . Intra class correlation coefficient showed a strong agreement between both methods, $r = 0.964$.

Table 2 : showing intra class coefficient test (ICC) comparing both methods. A value of more than 0.8 indicates perfect agreement.

Method	N	Mean	Std. Deviation	ICC	95% Confidence Interval	
					Lower Bound	Upper Bound
OCM	50	1.51	0.21	0.964	.937	.979
Kt/V (Dau)	50	1.53	0.22		.968	.990

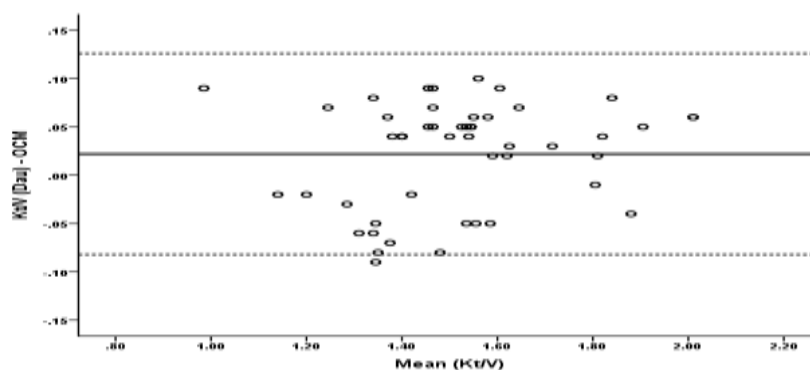


Figure 1: showing BLAND ALTMANT PLOT-comparing two methods .x axis is the average of the values and y axis the difference. The vertical line represents on average how much bias. All patients were within limits.

VI. Conclusions

In our study there is good correlation between Kt/V (D) and Kt/V (OCM). The Kt/V (D) measured by Daugirdas formulae was 1.53 ± 0.22 . The Kt/V(OCM) measured by online Clearance Monitor was 1.51 ± 0.21 . In the study Alaa A Sabry et al, the correlation coefficient between Kt/V online and calculated spKt/V urea measurement was 0.59¹⁴. In the study by Grzegorzewska AE et al, the sp Kt/V indicates a more adequate HD session than online Kt/V. Our study is unique in that it is done in Indian population. The dialysis dose was calculated for both methods in the same machine and during the same dialysis session.

The delivered dialysis dose should be regularly measured and monitored at least monthly using a standardized method. If the dialysis dose is determined, it is possible to prescribe and subsequently monitor the dialysis treatment on the basis of clinical parameters. The delivered dialysis dose should be expressed as sp Kt/V. The National Kidney Foundation NKF/DOQI recommends the minimum dose per session on a thrice weekly schedule approximately 1.2¹⁶. At times the prescribed dialysis dose is not delivered resulting in discrepancy between prescribed and delivered dose¹⁷. Certain factors such as sub optimal placement of AV needle, hemodynamic instability and malfunction of AV access prevent optimal dialysis delivery. The regular monitoring of Kt/V by Daugirdas method requires frequent blood samples, involvement of staff, syringes and laboratory costs. It is also inconvenient to the patient.

The requirement for monthly measurements of HD adequacy is a compromise between cost and the utility of the measurement. Online Clearance Monitor is a practical instrument for daily use and complements other formulas. The delivery of the dialysis dose can be monitored during dialysis and necessary modifications can be done during dialysis. It helps to adequate the dialysis dose delivered to reach excellent patient's benefit. According to European best practice guidelines on hemodialysis (2007), online clearance monitoring is an acceptable method for calculating hemodialysis on a treatment-by-treatment basis.

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