See editorial comment on page 147

Measuring Kt by ionic dialysance is a useful tool for assessing dialysis dose in critical patients

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ABSTRACT

Aim: To evaluate the Kt assessed through ionic dializance (KtOCM) in UCI patients undergoing renal replacement therapy for acute kidney injury, comparing the results with those obtained through the urea removal rate method determined by dialyzate collection (Kturea). **Material and methods:** 18 adult UCI staying individuals suffering from renal replacement therapy requiring oliguric acute kidney injury were included in this study. RRT consisted in intermitent or extended hemodialysis performed through a Fresenius 4008E dialysis machine equiped with an on-line clearance monitor (OCM Fresenius). The KtOCM results were provided automatically. The Spearman correlation test was used to assess the relationship between the two exploratory methods and the Student´s t test to compare the results obtained by the KtOCM and the Kturea. **Results:** 35 treatments were analyzed. There were not statistically significant differences between the results form the KtOCM and the Kturea (34.9 ± 10.69 vs 32.78 ± 11.31, p = NS). A remarkable association was find between both methods (r = 0.87; 95CI, 0.76-0.94; p <0.001). **Conclusions:** The assessment of Kt through ionic dialyzance is a simple method to estimate the dose of dialysis in critically ill patients and is and useful tool to monitor and adjust the RRT in real time according to a target dose.

Key words: Acute kidney injury. Dialysis dose. Kt. Kt/V. Urea reduction ratio. Ionic dialysance. OCM.

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La determinación del Kt por dialisancia iónica es una herramienta útil para la evaluación de la dosis de diálisis en pacientes críticos

RESUMEN

Objetivo: *Evaluar la determinación de Kt (KtOCM) por dialisancia iónica en los pacientes sometidos a terapia de reemplazo renal (TRR) por insuficiencia renal aguda (IRA) atendidos en una unidad de cuidados intensivos (UCI), comparándola con el Kt obtenido mediante el cálculo del índice de remoción de urea obtenido por recogida del dializado (Kturea).* ***Materiales y métodos:*** *Se incluyeron 18 pacientes adultos, con IRA oligúrica ingresados en la UCI, con requerimiento de TRR, tratados con hemodiálisis intermitente y/o diálisis extendida. Las TRR fueron realizadas con equipos Fresenius 4008E equipados con un monitor de aclaramiento «on-line» (OCM Fresenius). La determinación de KtOCM fue realizada automáticamente por el monitor. Se efectuaron la correlación y la comparación entre KtOCM y Kturea utilizando el análisis de correlación de Spearman y el test de la t, respectivamente.* ***Resultados:*** *Sobre 35 tratamientos efectuados, la media de KtOCM no fue estadísticamente diferente de la del Kturea (34,9 ± 10,69 frente a 32,78 ± 11,31; NS). Se obtuvo una importante correlación y una relación lineal significativa entre los dos métodos (r = 0,87; p <0,001; intervalo de confianza [IC] 95%, 0,76-0,94%).* ***Conclusiones:*** *La determinación del Kt por dialisancia iónica es un método simple para estimar la dosis de diálisis en pacientes críticos y es una herramienta útil para monitorizar y ajustar las TRR en tiempo real de acuerdo con una dosis objetivo.*

Palabras clave: *Insuficiencia renal aguda. Insuficiencia renal aguda. Dosis de diálisis. Kt. Kt/V. Porcentaje de reducción de urea. Dialisancia iónica. OCM.*

INTRODUCTION

Optimal doses of renal replacement therapy have not yet been established for patients with acute renal failure (ARF)

admitted to the intensive care unit (ICU).[1-3] In daily clinical practice, the final dose is not controlled and we generally do not reach the prescribed dosage,[4,5] unlike what happens with patients with end-stage renal disease. The Kt/V formula used systematically in patients with chronic kidney disease (CKD) has limitations when applied to critical patients, since they have a variable urea distribution volume which cannot be predicted.[6] Urea reduction ratio (URR) is easy to calculate, but it is calculated retrospectively and does not enable us to monitor whether or not the prescribed dose achieves its target level during treatment.[7] Calculating the dose of dialysis by directly measuring dialysate is a more reliable technique than other methods that can be applied in ARF.[8] A Kt reading can be taken by measuring urea concentration in dialysate without using urea distribution volume[9] but this requires collecting dialysate, which is a difficult step to carry out in daily practice. Determining Kt through ionic dialysance provides a direct measurement of the dialysis dose without using blood samples or collecting dialysate to determine urea concentrations, and it has been successfully done in patients with CKD.[10] Our objective, therefore, was to evaluate measuring Kt through ionic dialysance in ARF patients admitted to the ICU and compare the measurement with Kt obtained by calculating urea clearance from a collected dialysate sample.

MATERIAL AND METHODS

This prospective study included adult patients with oliguric ARF admitted to the ICU and requiring RRT, who were treated with intermittent haemodialysis and/or extended haemodialysis. Patient baseline characteristics were recorded, including severity of the ARF according to the individual severity index.[11]

The dialysis type and duration were not changed for purposes of the study, and were carried out according to the indication of the doctor responsible for the treatment. Patients received dialysis with Fresenius 4008 S monitors equipped with OCM biosensors (On-line clearance monitoring, Fresenius Medical Care AG). This device uses two conductivity probes to measure effective ionic dialysance in a non-invasive way. Filtered water for haemodialysis was provided by a portable reverse osmosis system (Apema S.R.L.®). The dialysis bath fluxes for intermittent haemodialysis and extended dialysis were 500 and 300ml/min, respectively. Sterile powdered bicarbonate was used. All RRT processes used 1.4m^2 helixone membranes. We used the Seldinger technique to place non-tunnel central venous access 11.5 Fr catheters, measuring 19 or 16cm in length, in the femoral or internal jugular veins respectively. Where there was no contraindication, patients were administered anticoagulation treatment with sodium heparin in a continuous infusion with a loading dose of 1000 U and a maintenance dose of 500 U/hour.

In each dialysis session, we took blood samples to determine plasma urea (PU) and total protein at the beginning and end of each treatment (using the slow-stop flow technique) in order to calculate the average urea concentration in plasma (PUmean).[12]

$$PUmean = (PUstart-PUend)/ln(PUstart/PUend)$$

where PUstart and PUend are the urea concentrations in plasma at the start and end of treatment.

Collecting dialysate was performed using the partial dialysate collection method.[13] Urea levels (Ud) and volume (Vd) of the dialysate were measured.

For calculating Kt using the urea clearance index obtained by sampling dialysate (Kturea), we used the following formula:

$$Kturea = (Vd\ Ud)/PUmean$$

where Vd = volume of dialysate, Ud = urea in dialysate and PUmean = mean urea concentration in plasma.

Kt determination using OCM (KtOCM) was performed automatically by the monitor at the end of the dialysis session.

Data used for statistical analysis are expressed as a mean ± standard deviation (SD). The correlation and comparison between KtOCM and Kturea was performed using Spearman's rank correlation test and the t-test, respectively.

RESULTS

The study included 18 patients receiving 35 treatments. Patients were 69 ± 16 years old, and 14 were men. The most frequent cause of the ARF was septic shock, followed by postsurgical ARF associated with cardiovascular surgery. Patient severity according to the ISI score was 0.67 ± 0.38; 13 patients required mechanical respiratory assistance and 12 were receiving inotropic drugs at the time of the consultation. Of the total treatments performed, 24 were intermittent haemodialysis sessions and 11 were extended haemodialysis sessions. The extended haemodialysis sessions had an average duration of 428 ± 36 minutes (range, 390-480 minutes). Patient and treatment characteristics are shown in Table 1.

The mean dialysis dose (Kt) measured by ionic dialysance (KtOCM) was not statistically different from that obtained

by measuring dialysate (Kturea) (KtOCM vs. Kturea, 34.9 ± 10.69 vs. 32.78 ± 11.31L [NS]).

We found an important correlation and a significant linear relationship between the two methods ($r = 0.87$; $p < 0.001$; 95% confidence interval [CI] 0.76-0.94%) (Figure 1).

DISCUSSION AND CONCLUSIONS

Severe ARF is present in 5-15% of patients admitted to the ICU, according to the at-risk population being studied and the ARF definition used.[14] ARF-associated mortality in critical patients admitted to the ICU ranges between 30 and 60%, depending on the series.[14] Although more than 60 years have passed since the first successful courses of dialysis were administered to patients with ARF, some important aspects in renal replacement are still topics for debate, such as when to begin RRT and what is the appropriate dose.[1]

In both patients with CKD and patients with ARF, RRTs were mainly measured in terms of urea kinetics, which serves as a substitute for other low-molecular weight solutes. In CKD patients, urea URR and Kt/V are the most commonly-used indexes. The urea kinetic model assumes stability characterised by a neutral nitrogen balance and similar predialysis urea values for each treatment cycle (haemodialysis). However, this is not valid for patients with ARF, since most critical patients are hypercatabolic and have a negative nitrogen balance.[15] Changes in regional blood flow, particularly when patients are haemodynamically unstable and require vasoactive drugs, may produce an imbalance in the intercompartmental urea distribution, which would invalidate the normally single-compartment urea models.[15] This imbalance would be less in patients treated with extended dyalisis,[16] and therefore the dialysis calculation obtained through the urea kinetic model could not be used to compare doses between intermittent and extended treatments. On the other hand, urea distribution volume in ARF patients is abnormal, and has a wide variation (between 7 and 50%) when compared with that found in patients with CKD.[7] A measurement of the amount of urea removed by dialysis based on a (urea) solute clearance index has been show to correlate well with Kt/V in CKD patients. On the other hand, in patients with ARF we see differences in the mass balance when comparing the dialysis dose calculated by measuring dialysate with that calculated by measuring blood levels, which shows that blood level measurement overestimates the amount of solute (urea) that is removed.[18] This is why measurements obtained by directly measuring solute clearance (taking a measurement from dialysate) is the method indicated in critical ARF patients, although it is difficult to apply in clinical practice.[9,18]

The use of Kt in CKD patients has been proposed, and it has been shown to have an excellent correlation with mortality in these patients.[9] Determining Kt using ionic dialysance has been successful in this population.[10]

Calculation of Kt obtained through ionic dialysance does not require use of the distribution volume. Likewise, is not influenced by urea imbalance, does not require any blood samples from the patient, and is calculated through direct measurement of solute clearance in dialysate, which is an alternative for determining dialysis dose in ARF patients admitted to the ICU. Furthermore, it allows us to compare resulting doses between cases of intermittent and extended dialysis.

In our study, use of ionic dialysance to determine Kt was evaluated by comparing the result with the method of reference for evaluating dialysis dosage in ARF patients. It was shown to have optimal correlation, with no significant differences between values obtained using the two methods. A single preliminary experience with ARF, listed in the references, used a different model from the one we used, and that study was limited to intermittent haemodialysis.[18] Our

Table 1. Patient and renal replacement therapy characteristics

Patients (n = 18)		**Treatments (n = 35)**	
Sex (male)	78%	Time (min)	273 ± 12
Age (years)	69 ± 16	Effective blood flow (ml/min)	186 ± 33
Septic shock	45%	Ultrafiltration (ml)	1284 ± 73
ISI score	0.67 ± 0.38	Intermittent haemodialysis	69%
		Extended haemodialysis	31%
Mechanical respiratory assistance	72%	Anticoagulation treatment	40%
Catecholamines	67%	Haemodialysis catheter	Femoral 62%
			Jugular 38%

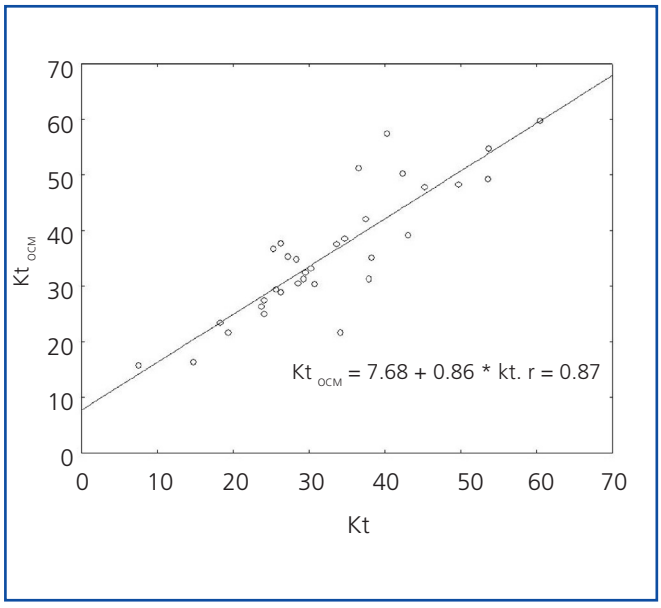

Figure 1. Correlation between Kt obtained through ionic dialysance (KtOCM) and Kt obtained by collecting dialysate.

own experience also included extended dialysis sessions, and showed that it was possible to use them for this type of RRT. It would be useful to run future studies comparing the effect of different ionic dialysance monitors for determining Kt, as has been done with CKD patients.[19]

Our study did not list evaluating the differences between actual doses and prescribed doses among its objectives, although we did see low Kt values in our results compared to those used as a reference for CKD patients;[9,10] it is already known that resulting doses are lower than prescribed doses in ARF patients, and the latter are often not monitored.[4,5] We know that catheter use is one of the factors requiring an increase in the dialysis time CKD patients need in order to reach the target Kt;[20] this would be more pronounced in the case of ARF, in which all patients use non-tunnel low-flux catheters.

In light of recent publications,[1-3] experts recommend a minimum target dose of dialysis, together with the use of quality control tools.[1] Use of Kt through ionic dialysance can be included among these tools to permit local control by each ICU, as a simple means of obtaining an objective value when comparing doses between different treatments or different ICUs.

To conclude, we feel that measuring Kt by ionic dialysance is a simple method for estimating dialysis dose in critical patients, and that it is a useful tool for monitoring and adjusting RRTs to a target dose in real time.

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