How much should dialysis time be increased when catheters are used?

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SUMMARY

The use of central catheters in hemodialysis patients as a permanent vascular access has increased during the last years, reaching numbers of around 7% of prevalent patients and between 25% of incident patients. Although the current catheters allow higher sanguineous flows with smaller incidence of infectious complications and dysfunction, the dose of dialysis that is reached is still inferior to that obtained with native arterio-venous fistula (AVF) and grafts. The aim of the present study was to evaluate the possible additional time supposed by dialysis using central venous catheters with respect to habitual vascular access as a consequence of the lesser blood flow (Qb) and the irregularity of its function (frequent lowering of the Qb and necessity of inverting the lines on many occasions). A total of 48 patients (31 men/17 women) with an average age of 61.6 ± 14 years old (rank: 28-83), 20 with tunnelled catheter and the remaining with AVF, were included in the study. All the patients were dialyzed in the modality of high flux hemodialysis with a polisulphone of 1.9 m² dialyzer, dialysis time of 240 minutes, dialysate flow 500 ml/min and monitors equipped with ionic dialysance (ID) with the objective of obtaining a Kt of 45 litres with each one of the different vascular accesses. The patients with AVF received 3 sessions, with variations of Qb to 300, 350 and 400 ml/min. The patients with tunnelled catheter received two sessions, to the maximum Qb, one with normal connection and other with inverted one. In the results obtained it is possible to emphasize that only the patients with AVF and 400 ml/min reached the objective of 45 L of Kt. The patients with AVF needed to increase 12 minutes of hemodialysis with a Qb of 350 ml/min and 28 minutes with a Qb of 300 ml/min; the catheters on normal position needed to increase 24 minutes and finally in the inverted catheters an increase of 59 minutes was necessary to reach the same Kt objective. We concluded that the patients dialyzed with central catheters on average needed to increase by 30 minutes the time of dialysis if the catheter worked in a normal position but 60 minutes if the arterio-venous lines were inverted so as to reach the minimum dose of dialysis.

Key words: *Dialysis dose. Kt. Time of dialysis. Tunnelled catheter.*

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RESUMEN

En los últimos años hemos observado un aumento progresivo en el porcentaje de pacientes de hemodiálisis que utilizan catéteres centrales tunelizados como acceso vascular permanente, situándose las tasas de prevalencia e incidencia entorno al 7 y 25%, respectivamente. A pesar de que los catéteres actuales permiten la obtención de mayores flujos sanguíneos y menores complicaciones infecciosas, las dosis de diálisis obtenidas resultan inferiores a las alcanzadas mediante la utilización de fístulas arterio-venosas nativas (FAV) y prótesis vasculares. El objetivo principal del presente estudio fue valorar el tiempo adicional para obtener una dosis óptima de diálisis mediante la utilización de catéteres centrales venosos tunelizados. Dicha premisa se basa en la obtención de menores flujos sanguíneos (Qb) así como de posibles disfunciones vasculares que en diferentes ocasiones obligan a invertir las líneas arterio-venosas. Se analizaron un total de 48 pacientes (31 varones/17 mujeres) con una edad media de 61,6 ± 14 años (rango: 28-83); 20 con catéteres centrales tunelizados y 28 con FAV nativas. Todos los pacientes incluidos en el estudio se dializaron con la modalidad de hemodiálisis de alto flujo, con polisulfona de 1,9 m², con una duración de 240 minutos, con flujo baño a 500 ml/min y monitores equipados con dialisancia iónica (DI). El objetivo principal de análisis fue la obtención de un Kt de 45 litros con cada uno de los diferentes accesos vasculares. Los pacientes portadores de una FAV recibieron 3 sesiones con variaciones de Qb a 300, 350 y 400 ml/min. Los pacientes con catéteres tunelizados recibieron dos sesiones de diálisis al máximo Qb, una con conexión de líneas normales y otra con líneas invertidas. Entre los resultados obtenidos cabe destacar que sólo los pacientes portadores de una FAV con un Qb de 400 ml/min alcanzaron el objetivo de Kt de 45 litros. Los sujetos con FAV precisaron incrementar 12 minutos de hemodiálisis con Qb de 350 ml/min y 28 minutos con Qb de 300 ml/min; los catéteres tunelizados en posición normal 24 minutos y los invertidos un total de 59 minutos. Concluimos que los pacientes dializados con catéteres centrales venosos tunelizados necesitan para alcanzar una dosis mínima de diálisis (Kt de 45 litros), incrementar por término medio 30 minutos el tiempo de la sesión si funciona en posición normal y 60 minutos en posición invertida de líneas arterio-venosas.

Palabras clave: Catéter tunelizado. Dosis óptima de diálisis. Kt. Tiempo de diálisis.

INTRODUCTION

In European countries, there has been in recent years a gradual increase in use of tunneled central venous catheters as a modality of permanent vascular access. According to the results reported by the DOPPS study,[1] their prevalence and incidence rates are approximately 7% and 25% respectively. In our environment,[2] the proportion of incident patients on hemodialysis with catheters increased at the end of the 90s from 49.5% to 55.3%, and while indwelling catheters were virtually nonexistent in 1997, they were implanted in 17.1% of patients in 2004. The proportion of prevalent patients with catheters, which was less than 8% in the 90s, has also doubled in 10 years. This exponential increase is due to the greater longevity of the current population in hemodialysis programs, as well as to late referral to the specialist and to a higher prevalence of metabolic cardiovascular disease, mainly occurring as arterial hypertension and diabetes mellitus.[3] Placement of tunneled catheters is a good alternative for definitive vascular access in patients in whom a native arteriovenous fistula (AVF) cannot be performed or a vascular prosthesis cannot be implanted for anatomical reasons. Placement of tunneled catheters is technically simple, and they may be used immediately.[4] Although blood flows (Qb) reached with tunneled catheters are increasingly high, the dialysis doses achieved are still lower than those achieved with native AFVs or vascular prostheses. This is probably related to this lower Qb and a higher number of complications associated to vascular dysfunctions and infectious processes.[5-7]

The primary objective of this study was to assess the additional time required to achieve an optimal dialysis dose when tunneled central venous catheters are used. Such additional time results from the lower blood flow achieved and the potential vascular changes, often requiring a decrease in Qb and the need for reversal of arteriovenous lines.

PATIENTS AND METHODS

A total of 48 patients (31 males and 17 females) with a mean age of 61.6 ± 14 years (range: 28-83) were analyzed. Patients over 18 years of age without residual kidney function on a stable hemodialysis program were enrolled into the study. There were no exclusion criteria, but 2 sessions where a great catheter dysfunction was seen were ruled out. Causes of chronic renal failure included nephroangiosclerosis (13 patients), diabetes mellitus,[11] tubulointerstitial nephropathy,[5] chronic glomerulopathy,[5] polycystic kidney disease,[5] systemic disease (3 patients with SLE, multiple myeloma, and primary amyloidosis), bilateral nephrectomy, and unknown (5 patients). Table I shows the age, sex, and underlying conditions of the AVF and catheter groups. Among patients enrolled into the study, 20 had tunneled central venous catheters and 28 AVFs (26 natives AVFs and two PTFE prostheses). Tunneled catheter models were as follows: 12 Arrow®, 4 Split-Cath® (Medcomp®), 2 Permcath® (Medcomp®), and 2 Canaud® (Quinton®). Nine catheters were located in the right internal jugular vein, 8 in the left internal jugular vein, and 3 in the right femoral vein.

All patients enrolled into the study underwent high flux hemodialysis with a polysulphone 1.9 m^2 dialyzer for 240 minutes with a dialysate flow of 500 mL/min. 4008 S (Fresenius) and Integra (Hospal) monitors, fitted with OCM (on-line clearance monitoring) or Diascan biosensors, were used in 42 and 6 patients respectively. Biosensors provide a noninvasive measurement of effective ionic dialysance (ID), which is equivalent to urea clearance.

Table I. Distribution of patient groups by age, sex, and etiology of renal failure

	AVF	Catheter
Patients (n)	28	20
Age	59.0 ± 15	67.0 ± 11
Sex (male/female)	19 (68%)/9 (32%)	12 (60%)/8 (40%)
Etiology	6 (21.4%)	7 (35.0%)
Vascular nephropathy	4 (14.3%)	7 (35.0%)
Diabetic nephropathy	4 (14.3%)	1 (5.0%)
Glomerulonephritis	4 (14.3%)	1 (5.0%)
Tubulointerstitial nephropathy	4 (14.3%)	2 (10.0%)
Policistic kidney disease	3 (10.7%)	0
Systemic disease	3 (10.7%)	1 (5.0%)
Urological disease	0	1 (5.0%)
Unknown		

The primary objective was to achieve a Kt of 45 L with each of the different vascular accesses. Patients with tunneled catheters received two dialysis sessions at maximum Qb, one with a normal line connection and the other with the lines reversed. Patients with AVFs underwent 3 sessions, in which Qb was changed to 300, 350 and 400 mL/min. Baseline ID, final ID, and Kt were recorded in each dialysis session.

Results are given as the arithmetic mean ± standard deviation. A Student's t test for independent data was used to analyze the statistical significance of quantitative parameters (figs. 1 and 2). A value of $p < 0.05$ was considered statistically significant.

RESULTS

The Qb values in the group of patients with tunneled catheters were 320 ± 42 mL/min in the normal position and 309 ± 46 mL/min in the reverse position. Baseline IDs were 181 ± 21 mL/min and 160 ± 20 mL/min with the catheter in the normal and reverse positions respectively ($p < 0.01$). In patients with native AVFs, baseline ID values were 178 ± 12, 190 ± 11, and 199 ± 17 mL/min with Qbs of 300, 350, and 400 mL/min respectively. In patients with tunneled catheters, final ID values were 163 ± 26 mL/min in the normal position and 141 ± 19 mL/min in the reverse position ($p < 0.01$). In patients with native AVFs, final ID values were 163 ± 16, 174 ± 10, and 179 ± 12 mL/min with Qbs of 300, 350, and 400 mL/min respectively. Figure 1 shows the baseline and final ID values obtained in patients with tunneled catheters and AVFs.

Mean clearance (K) was 171 ± 19 mL/min and 151 ± 12 mL/min with the tunneled catheter in the normal and reverse positions respectively. In patients with AVFs, mean K values

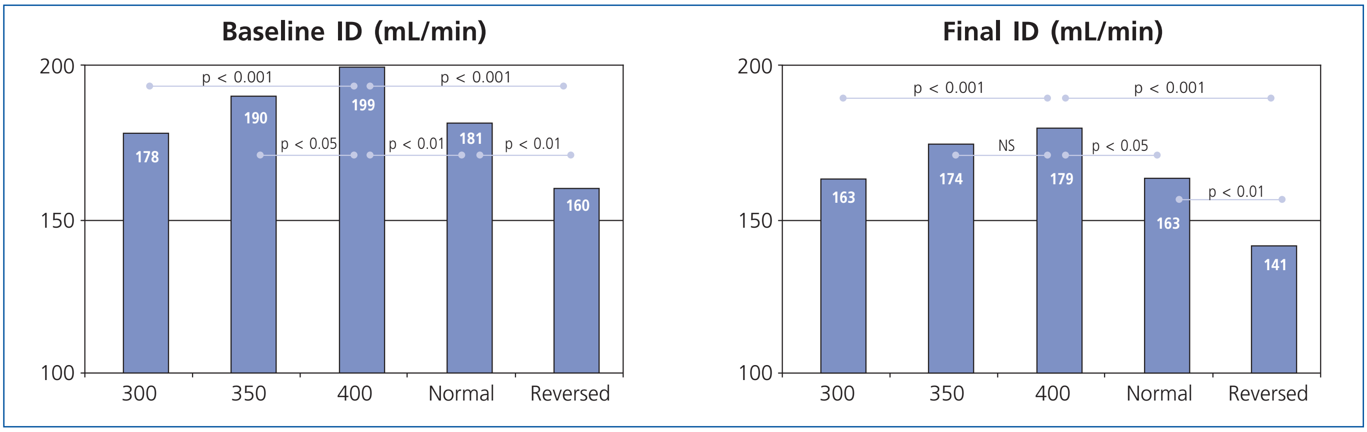

Figure 1. Results of baseline and final ID by vascular access. AVF at 300, 350, and 400 ml/min and catheter in the normal and reverse positions.

were 168 ± 12, 179 ± 10, and 187 ± 11 mL/min with Qbs of 300, 350, and 400 mL/min respectively. The Kt results at session end were 40.9 ± 5 L with the catheter in normal position and 36.1 ± 4 L with the catheter reversed. Patients with AVFs achieved Kt values of 40.3 ± 3, 42.9 ± 2, and 45.0 ± 2.5 L with Qbs of 300, 350, and 400 mL/min. Figure 2 shows the Kt values obtained in patients with tunneled catheters and AVFs. Only patients with AVFs with a Qb of 200 mL/min reached the goal of a Kt of 45 L, with statistically significant differences being seen with all other vascular accesses (fig. 2). In patients with AVF, 12- and 28-minute longer hemodialysis times were required with Qb values of 350 mL/min and 300 mL/min respectively; the corresponding times for tunneled catheters in the normal and reverse positions were 24 and 59 minutes respectively. Table II summarizes the additional dialysis times required to achieve a Kt of 45 L by vascular access.

DISCUSSION

This study analyzed the additional time needed to achieve an optimal dialysis dose in patients with catheters using ID. An analysis of 48 patients, 20 of them with tunneled catheters, showed that additional dialysis times of 30 and 60 minutes were respectively required on average with the arteriovenous lines in the normal and reverse positions to achieve a Kt of 45 L. This is a crucial fact considering the gradual increase in the mean age of incident patients on hemodialysis, 80% of whom are older than 65 years.[8] The immediate consequence is an increase in the proportion of temporal and indwelling catheters,

Table II. Additional time required to achieve a Kt of 45 L

Vascular access	Additional time
AVF and Qb 400 mL/min	240 min (reference 45 L of Kt)
AVF and Qb 350 mL/min	Increase by 12 minutes
AVF and Qb 300 mL/min	Increase by 28 minutes
Normal catheter connection	Increase by 25 minutes
Catheter with reversed connection	Increase by 59 minutes

higher than 50% at the start of hemodialysis.[2] This has resulted in an increase in vascular access complications such as thrombosis and infectious processes and in lower dialysis doses, leading to a higher morbidity and mortality and to an increase in current financial costs.[4,9-11]

While the Qbs achieved with tunneled catheters are increasingly high as compared to temporal catheters, different studies have concluded that they provide a lower dialysis dose.[12,13] In this regard, the Canaud et al study[5] reported interesting results showing a 5%-6% reduction in Kt/V in the group of patients using catheters. There are different reports in the literature showing that inadequate hemodialysis doses are achieved with blood flows lower than 300 mL/min.[6]

Current technological advances in hemodialysis allow for *in situ,* real time follow-up of the course of the hemodialysis session to monitor dialysis dosing and to improve dialysis tolerance. In this regard, different monitors now incorporate biosensors that measure noninvasively, using the conductivity probes of the machines, the effective ionic dialysance, which is equivalent to urea clearance (K), thus allowing for calculation of the dialysis dose without work overload, laboratory measurements, or additional cost.[14] Systematic K measurement by the dialysis time elapsed allows for obtaining Kt, an actual measure of the dialysis dose, expressed in liters. Use of

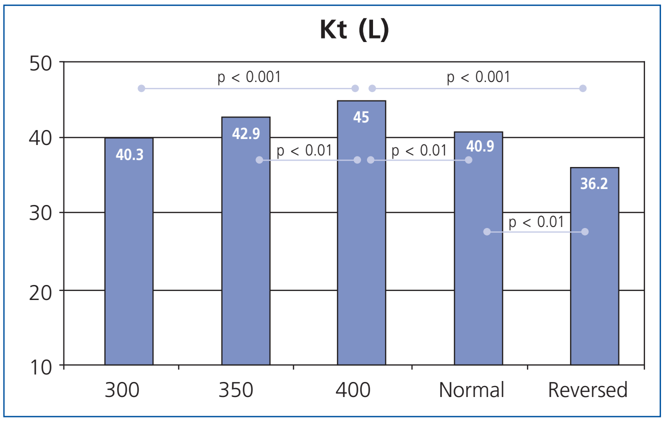

Figure 2. Kt results by vascular access and with different blood flows. AVF at 300, 350, and 400 mL/min and catheter in the normal and reverse positions.

Kt has advantages, because both K and t are actual values measured by the monitor. If Kt/V is used, we should introduce V, and thus a value that is almost always erroneous and may be manipulated during the session. Sin 1999, Lowrie et al[15,16] propose Kt as the marker of dialysis dose and mortality, recommending a minimum Kt of 40-45 L for females and 45-50 L for males. Chertow et al[17] noted in 3,009 patient a J-shaped survival curve when they were distributed into quintiles based on PRU, whereas a descending curve was found when Kt was used, i.e. a higher Kt was associated to an increased survival. According to the results obtained in a previous study[14] that analyzed with ID a total of 1,606 sessions in 51 patients, from 30% to 40% of patients did not reach an adequate dose, expressed as Kt, for their sex or body surface area. Significantly, this recommended dose was not reached in 7 of the 11 patients with implanted catheters (64%).

Because of the limited number of patients enrolled into the study, differences by catheter location and type could not be assessed.

We conclude that dialyzed patients with central catheters need adjustments in dialysis time prescriptions. Because of the great dose variability between hemodialysis sessions when a catheter is used, use of monitors with ionic dialysance should ideally be generalized and Kt should be measured in each session to ensure adequate hemodialysis. When monitors allowing for Kt follow-up are not available, hemodialysis time would have to be increased, on average, by 30 minutes when a catheter is used in the normal position and by 60 minutes when in a reverse position.

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