Kt as control and follow-up of the dose at a hemodialysis unit

F. Maduell, M. Vera, N. Serra, S. Collado, M. Carrera, A. Fernández, M. Arias, M. Blasco, E. Bergadá, A. Cases and J. M.ª Campistol

Department of Nephrology. Hospital Clínic Barcelona.

Nefrología 2008; 28 **(1)** 43-47

SUMMARY

To ensure our patients are receiving an adequate dose in every dialysis session there must be a target to achieve this in the short or medium term. The incorporation during the last years of the ionic dialysance (ID) in the monitors, has provided monitoring of the dialysis dose in real time and in every dialysis session. Lowrie y cols., recommend monitoring the dose with Kt, recommending at least 40 L in women and 45 L in men or individualizing the dose according to the body surface area. The target of this study was to monitor the dose with Kt in every dialysis session for 3 months, and to compare it with the monthly blood test. 51 patients (58% of our hemodialysis unit), 32 men and 19 women, 60.7 ± 14 years old, in the hemodialysis programme for 37.7 ± 52 months, were dialysed with a monitor with IC. The etiology of their chronic renal failure was: 3 tubulo-interstitial nephropathy, 9 glomerulonephritis, 12 vascular disease, 7 polycystic kidney disease, 7 diabetic nephropathy and 13 unknown. 1,606 sessions were analysed during a 3 month period. Every patient was treated with the usual parameters of dialysis with 2.1 m² cellulose diacetate (33.3%), 1.9 m² polisulfone (33.3%) or 1.8 m² helixone, dialysis time of 263 ± 32 minutes, blood flow of 405 ± 66, with dialysate flow of 712 ± 138 and body weight of 66.7 ± 14 kg. Initial ID, final ID and Kt were measured in each session. URR and Kt/V were obtained by means of a monthly blood test. The initial ID was 232 ± 41 ml/min, the final ID was 197 ± 44 ml/min, the mean of Kt determinations was 56.6 ± 14 L, the mean of Kt/V was 1.98 ± 0.5 and the mean of URR was 79.2 ± 7%. Although all patients were treated with a minimum recommended dose of Kt/V and URR when we used the Kt according to gender, we observed that 31% of patients do not get the minimum dose prescribed (48.1 ± 2.4 L), 34.4% of the men and 26.3% of the women. If we use the Kt individualized for the body surface area, we observe that 43.1% of the patients do not get the minimum dose prescribed with 4.6 ± 3.4 L less than the dose prescribed. We conclude that the monitoring of dialysis dose with the Kt provides a better discrimination detecting that between 30 and 40% of the patients perhaps do not get an adequate dose for their gender or body surface area.

Key words: *Adequacy. Dialysis dose. Ionic dialysance. Kt. On-line monitoring.*

RESUMEN

Asegurar que el paciente recibe la dosis adecuada en cada sesión de diálisis debe ser un objetivo a conseguir a corto o medio plazo. La incorporación de la dialisancia iónica (DI) en los monitores durante los últimos años ha permitido monitorizar la dosis de hemodiálisis en tiempo real y en cada sesión. Lowrie y cols., recomiendan el seguimiento de la dosis con el Kt, recomendando un mínimo de 40 L en mujeres y 45 en hombres o individualizar la dosis por área de superficie corporal. El objetivo del presente estudio era hacer un seguimiento de la dosis con el Kt en cada sesión durante 3 meses, y comparar con la analítica mensual habitual. 51 pacientes (58% de la Unidad de hemodiálisis), 32 varones y 19 mujeres, de 60,7 ± 14 años de edad, en programa de hemodiálisis durante 37,7 ± 52 meses, se dializaron con monitor con DI de forma rutinaria. La etiología de su IRC era de 3 NTI, 9 GNC, 12 nefroangiosclerosis, 7 poliquistosis renal, 7 diabetes mellitus y 13 no filiada. Se analizaron 1.606 sesiones durante 3 meses. Cada paciente recibió la pauta habitual de HD, con dializadores de diacetato de celulosa de 2,1 m² (33,3%), polisulfona de 1,9 m² (33,3%) y helixona de 1,8 m², con duración de 263 ± 32 minutos, con un flujo sanguíneo de 405 ± 66, con flujo baño a 712 ± 138 ml/min, peso seco de 66,7 ± 14 kg. Se valoró la DI inicial, la DI final y el Kt en cada sesión y el PRU y el Kt/V mediante la analítica mensual. La DI inicial fue de 232 ± 41 ml/min, la DI final de 197 ± 44 ml/min, la dosis media de Kt fue de 56,6 ± 14 L, el Kt/V medio de 1,98 ± 0,5 y el PRU de 79,2 ± 7%. Todos los pacientes recibieron una dosis mínima de Kt/V y PRU de 1,3 y 70%, respectivamente. No obstante, si utilizamos el Kt según el sexo, observamos que el 31% de los pacientes no alcanzaban la dosis mínima prescrita (48,1 ± 2,4 L), 34,4% de los hombres y el 26,3% de las mujeres. Si utilizamos el Kt individualizado por su superficie corporal, (49,1 ± 4 L), observamos que el 43.1% de los pacientes no alcanzaban la dosis mínima prescrita, con 4,6 ± 3,4 L menos de dosis. Concluimos que el seguimiento de la dosis de diálisis con el Kt, permite una mejor discriminación de la adecuación de diálisis, identificando entre el 30 y el 40% de pacientes que quizá no alcanzasen una dosis adecuada para su género o para su superficie corporal.

Palabras clave: Adecuación. Dialisancia iónica. Dosis de diálisis. Kt. Monitorización on-line.

Correspondence: *Francisco Maduell Canals.*
fmaduell@clinic.ub.es
Hospital Clínic de Barcelona. Villarroel, 170. 08036 Barcelona

INTRODUCTION

At each hemodialysis process several factors take place that may have an influence on the dialytic efficacy, so that it seems reasonable that control systems have been created in order to quantify at real time and at each session the dose the patient is receiving. In this sense, different monitoring devices have currently incorporated biosensors that measure in a non-invasive way, and using the conductivity probes of the devices, the effective ionic dialysance, which is equivalent to urea clearance (K), and thus it allows calculating the dialysis dose without additional workload, analytical determinations, or cost.[1-3]

Systematic determination of K by the time on dialysis allows obtaining the Kt, a real way of measuring the dialysis dose, expressed in liters. Working with the Kt has advantages since K and t are real and measured by the monitoring device. If we prescribe a Kt/V we have to introduce V, and thus an almost always wrong value that may be manipulated during the session.

Since 1999, Lowrie et al.[4] proposed the Kt as a marker of the dialysis dose and mortality, recommending a minimum Kt of 40-45 liters for women and 45-50 for men. In a study on 3,009 patients,[5] the authors observed a J-shaped survival curve when the categorized the patients by PUR quintiles, whereas the curve was descendent when the Kt was used, that is to say, a higher Kt value was accompanied by higher survival. In the year 2005, the Kt prescription was adjusted to the body surface area,[6] which was validated in a further study.[7] The aim of the present study was to undertake a follow-up of the dialysis dose with the Kt at each session for 3 months, and to assess the adherence to prescriptions and usual recommendations, for both those based on the monthly laboratory work-up and those referred to the Kt.

PATIENTS AND METHODS

This is a prospective study including 51 patients, 58% from the Hemodialysis Unit, 32 males and 19 women, aged 60.7 ± 14 years (range 28-82 years), on hemodialysis program for 37.7 ± 52 months, and dialyzed with ionic dialysance-equipped monitor. The only inclusion criteria were the availability of ionic dialysance-equipped monitors. The etiology of chronic renal failure was tubulointerstitial nephropathy,[3] chronic glomerulopathy,[9] nephroangiosclerosis,[12] polycystic renal disease,[7] diabetes mellitus,[7] and of unknown origin.[13] Every patient received a usual hemodialysis regimen with dialyzers of 2.1-m^2 diacetate cellulose (33.3%), 1.9-m^2 polysulphone (33.3%), and 1.8-m^2 helixone, with a mean duration of 263 ± 32 minutes (range 180-300), and blood flow of 405 ± 66 mL/min (range 300-500), and bath flow at 712 ± 138 mL/min, dry weight 66.7 ± 14 kg. The vascular access was as follows: 40 arterial-venous fistulas (38 endogenous and 2 PTFA prostheses), and 11 central funneled catheters. The residual renal function was considered negligible.

The patients were dialyzed with monitors 4008 S (Fresenius) or Integra (Hospal) equipped with OCM (On-line clearance monitoring) or Diascan biosensors, respectively, which non-invasively measure the effective ionic dialysance equivalent to urea clearance by using conductivity probes. By taking two measurements of the fluid conductivity and the dialyzer inlet and outlet, a mathematic model is applied of two equations for two unknown values, which allows knowing the effective ionic dialysance corrected for ultrafiltration and recirculation through the vascular access.

At each dialysis session, initial ionic dialysance, final ionic dialysance, and Kt were recorded. On a monthly basis, the second generation Daurgidas Kt/V was calculated from routine laboratory work-up and the percentage of urea reduction (PUR). A follow-up of the dialysis dose administered was done, as well as of adherence to the recommendations on dialysis dosing:

- Recommendations from the main Clinical Guidelines, the most widely used to date: Kt/V > 1.3 and/or PUR > 70%.[8-10]
- Gender-adjusted recommendations: Kt/V > 1.3 in men and 1.6 in women.[11-12]
- Recommendation of Kt > 45 liters according to the SEN Guidelines.[10]
- Recommendation of Kt 40-45 L in women and Kt 45-50 L in men, within the recommended upper limit, Kt > 45 L in women and Kt > 50 L in men.[4]
- Recommendation of Kt adjusted by body surface area.[6]

These recommendations individualized for each patient and body surface area (BSA) are shown in table 1.

The results are expressed as arithmetic mean + standard deviation. The Student's t test has been used for the analysis of statistical significance of quantitative parameters. A p value < 0.05 has been considered to be statistically significant.

RESULTS

One thousand six hundred and six sessions with ionic dialysance from the 51 patients included during a follow-up period of 3 moths were recorded, whereas analytical samples were obtained at 153 sessions (one per month per patient). Due to logistic problems dealing with changes to spare monitors or technical problems, ionic dialysance could not be recorded at every dialysis session.

About the follow-up at each dialysis session, mean initial ID was 232 ± 41 mL/min (range: 145-313 mL/min), and mean final ID was 197 ± 44 mL/min (range: 122-254 mL/min). The mean Kt dose was 56.6 ± 14 L (range: 34.8-88.3 L).

By means of monthly laboratory work-up, we obtained a mean Kt/V value of 1.98 ± 0.5 (range: 1.30-3.20) and a mean PUR value of 79.2 ± 7% (range: 65-92%). The graphical plotting of the dose obtained by monthly laboratory work-up (153 measurements) and that obtained by Kt at each session (1606 measurements) is shown in Figure 1. The Kt during the first month was 57.2 ± 14 L, during the second one 56.4 ± 13.7, and during the third one 55.9 ± 13.7. It is observed that the dose was kept constant during the three follow-up months with both ID determinations and laboratory work-up.

All patients received a minimal Kt/V dose of 1.3, although when analyzing by gender only two women did not reach a minimal Kt/V of 1.6. Ninety percent of the patients obtained a PUR ≥ 70%, and five patients did not reach that target. About

Table I. Minimal dialysis dose prescription targets adjusted by gender and body surface area (BSA)

	Gender	Weight (kg)	BSA (m^2)	Kt/V	PUR (%)	Kt (gender)	Kt (BSA)
1	Male	85.0	2.03	1.3	70	50	54.0
2	Female	65.0	1.76	1.3	70	45	49.2
3	Female	46.5	1.42	1.3	70	45	42.4
4	Female	66.0	1.70	1.3	70	45	48.0
5	Male	53.0	1.58	1.3	70	50	45.7
6	Male	71.0	1.82	1.3	70	50	50.3
7	Male	53.0	1.74	1.3	70	50	48.8
8	Female	53.5	1.50	1.3	70	45	44.1
9	Female	66.5	1.75	1.3	70	45	49.0
10	Female	68.5	1.78	1.3	70	45	49.5
11	Male	78.0	1.93	1.3	70	50	52.2
12	Male	72.5	1.86	1.3	70	50	51.0
13	Male	68.0	1.83	1.3	70	50	50.2
14	Male	75.0	1.94	1.3	70	50	52.4
15	Male	68.0	1.79	1.3	70	50	49.6
16	Male	91.0	2.10	1.3	70	50	55.1
17	Female	46.0	1.41	1.3	70	45	42.0
18	Male	73.0	1.86	1.3	70	50	51.0
19	Male	60.0	1.67	1.3	70	50	47.7
20	Female	70.5	1.81	1.3	70	45	49.9
21	Female	49.0	1.45	1.3	70	45	42.9
22	Male	99.0	2.20	1.3	70	50	56.8
23	Male	73.0	1.95	1.3	70	50	52.4
24	Female	97.0	2.19	1.3	70	45	56.7
25	Male	78.0	1.97	1.3	70	50	53.1
26	Male	45.0	1.43	1.3	70	50	42.4
27	Female	43.0	1.34	1.3	70	45	40.7
28	Male	73.0	1.82	1.3	70	50	50.3
29	Female	46.0	1.44	1.3	70	45	42.9
30	Female	47.0	1.43	1.3	70	45	42.9
31	Male	78.5	2.01	1.3	70	50	53.7
32	Male	52.0	1.55	1.3	70	50	45.3
33	Male	69.5	1.86	1.3	70	50	51.3
34	Female	77.0	1.90	1.3	70	45	51.7
35	Male	72.5	1.86	1.3	70	50	51.0
36	Male	65.0	1.78	1.3	70	50	49.5
37	Female	65.5	1.70	1.3	70	45	48.0
38	Female	53.0	1.57	1.3	70	45	45.7
39	Male	87.5	2.07	1.3	70	50	54.7
40	Male	72.0	1.88	1.3	70	50	51.3
41	Male	60.0	1.69	1.3	70	50	48.0
42	Female	49.0	1.52	1.3	70	45	44.5
43	Male	79.0	1.99	1.3	70	50	52.0
44	Female	69.0	1.74	1.3	70	45	48.8
45	Male	77.0	1.92	1.3	70	50	52.0
46	Male	72.0	1.71	1.3	70	50	48.4
47	Male	73.5	1.88	1.3	70	50	51.3
48	Male	68.5	1.82	1.3	70	50	50.3
49	Female	47.0	1.42	1.3	70	45	42.4
50	Male	72.0	1.87	1.3	70	50	51.3
51	Male	63.5	1.72	1.3	70	50	48.4

the recommendations on Kt prescription, 78% of the patients reached a minimum of 45 L. However, if we use the gender-adjusted Kt as the reference, 31% of the patients did not reach the minimal prescribed dose (48.1 ± 2.4 L), 34.4% of male patients and 26.3% of female patients. Finally, if we adjust the prescriptions to the Kt adjusted by body surface area, 49.1 ± 4 L, we observed that 43.1% of the patients did not reach the minimal prescribed dose, with 4.6 ± 3.4 L lower dose than prescribed, in 14 patients the difference was < 5 liters and in 8 patients > 5 liters (table II).

The vascular access had an influence on the dose reached. Patients dialyzed through an arterial-venous fistula (40 patients) had a mean Kt of 59.2 ± 14 L, whereas in those dialyzed through a central funneled catheter (11 patients) the mean Kt was 46.9 ± 5 L, of whom seven did not reach the prescribed dose. The differences by time, Qb, Qd, and dose between both groups are shown in table III.

DISCUSSION

The present work shows a different, more stringent, way of carrying out the control and follow-up of the dialysis dose. It is different both because of the way of determining the dose (Kt expressed in liters) and because of the close follow-up at

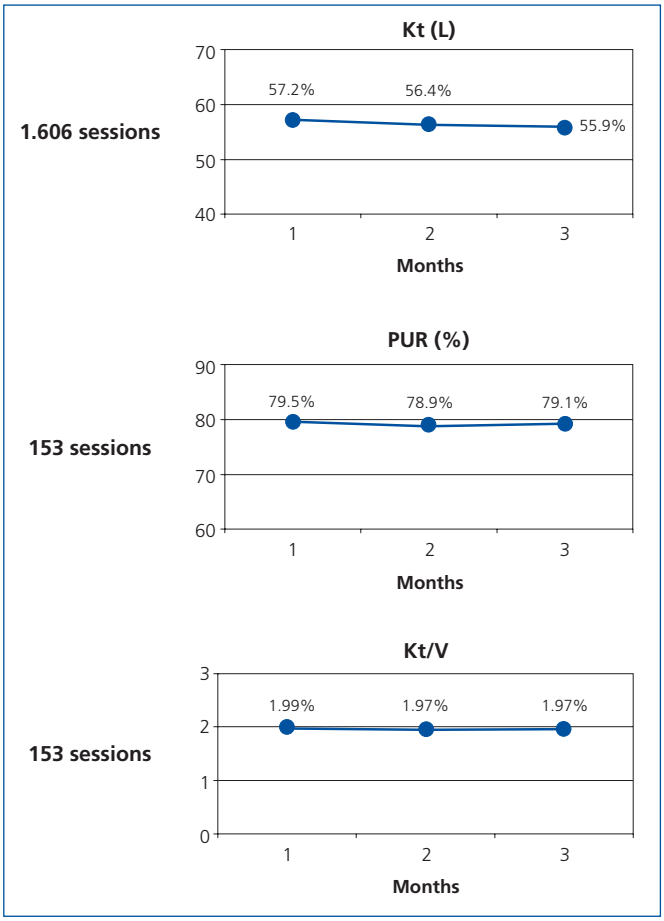

Figure 1. Monthly progression of the dose expressed in Kt/V, percentage of urea reduction, and Kt.

every dialysis session. The higher demand placed comes from the fact that by comparing with the usual analytical recommendations, the adherence the minimal Kt dose was not reached in 30% and 40% of the study patients when adjusting by gender or body surface area, respectively.

The current recommendations on the dialysis dose are based on monthly analytical determinations, although many times they are done every 3 to 6 months. An American multicenter study recommends a Kt/V ≥ 1.3 and/or PUR of 70%.[8] According to the hemodialysis practice guidelines (DOQI) of the National Kidney Foundation, a minimum Kt/V of 1.2 and/or PUR of 65% is recommended, although the ideal should be a Kt/V of 1.3 and PUR of 70% in order to assure these minimal requirements.[9] These recommendations are also recommended by the European,[13] Canadian,[14] British,[15] and Spanish Guidelines of the Spanish Society of Nephrology.[10]

Using the Kt offers some advantages: both K and t are real-time measurements from the monitor, which cannot be manipulated by the user and they may be used at every dialysis session with no additional cost. The J-shaped survival curve that occurs when the patients are categorized in quintiles by the PUR or Kt/V values[5] is avoided, and we may identify a subgroup of patients that seem to be receiving a high dialysis dose if measured by the Kt/V or PUR, but which may be considered under-dialyzed if we use the Kt. In 1999, the initial recommendations were done according to gender, with a minimal Kt of 40-45 liters in women and 45-50 in men;[4] in the year 2005, they were individualized by body surface area.[6] Later on, these indications were valid[7] observing that patients receiving 4-7 liters less than those prescribed increased their mortality by 10%, in those with 7-11 liters less the mortality was increased by 25%, and in those receiving ≥ 11 liters less than prescribed the mortality was increased by 30%. In the present study we observe that following the classical prescriptions of Kt/V or PUR, almost all patients received the recommended dose, whereas if we used the Kt only 60%-70% of the patients reached the target dose, these patients having lower dry weight and a catheter as their vascular access.

Different studies having used ionic dialysance in hemodialysis expressed it as the Kt/V, and they concluded that the Kt/measured by ionic dialysance is different from the Kt/V measured by laboratory work-up, although there exists a co-

Table III. Variations in the dialysis dose by type of vascular access

	iAVF (n = 40)	Catheter (n = 11)	SIG
Td (min)	260 ± 33	275 ± 26	NS
Qb (mL/min)	419 ± 64	354 ± 47	P < 0.01
Qd (mL/min)	740 ± 121	609 ± 151	P < 0.01
Kt/V	2.05 ± 0.50	1.86 ± 0.54	NS
PUR (%)	79.9 ± 7	76.7 ± 7	NS
Kt (L)	59.2 ± 14	46.9 ± 5 L	P < 0.001

Table II. Differences between the prescribed dose and the dose reached according to the different recommendations

	Dose prescribed	Dose reached	Patients adhering	% of patients adhering
Kt/V > 1,3	1.3	1.98 ± 0.5	51	100%
PUR > 70%	70	79.2 ± 7	46	90%
Kt > 45 L	45	56.6 ± 14	40	78%
Kt Women > 45L Men > 50L	48.1 ± 2	53.4 ± 12 58.5 ± 14	35	69%
Kt by BSA	49.1 ± 4	56.6 ± 14	29	57%

rrelation,[16-19] similarly to what happens with hemodiafiltration,[20] showing that there exists an inter-method variability. In order to obtain the Kt/V it is necessary to introduce the V, a very inaccurate value that may be obtained by anthropometrical equations such as Watson's, by calculating the measured Kt divided by the analytical Kt/V,[21] or by bioimpedanciometry.[22] Other methods using total or partial collection of the dialysis fluid[23-25] are more accurate although less practical to be used in routine clinical practice. The Kt/V determined by ionic dialysance usually yields an underestimation when compared with the Kt/V calculated by the second-generation Daurgidas' formula obtained from the laboratory data.

Another issue deserving our attention is that working with ionic dialysance increases the accuracy of the results since the measurements are done at each dialysis session. In the present study, using the Kt for dose follow-up was done in more than 1600 sessions as compared with 153 analytical measurements, which represent a monthly determination per patient according to the recommendations contained in the K-DOKI guidelines.[9] Generalizing the use of the Kt will allow an accurate comparison of the different groups of hemodialysis patients.

We may conclude that the follow-up of the dialysis dose by using the Kt achieves an adequate control of the dialysis dose, allows for better discrimination of adequacy to dialysis, and identifies 30% to 40% of the patients not reaching their target dose by gender or body surface area, respectively. Its use is recommended in a routine way in all patients usually receiving dialysis with monitors measuring the ionic dialysance.

REFERENCES

1. Peticlerc T, Goux N, Reynier AL, Bene B. A model for non invasive estimation of *in vivo* dialyzer performances and patient's conductivity during hemodialysis. *Int J Artif Organs* 16: 585-591, 1993.
2. Steil H, Kaufman AM, Morris AT, Levin NW, Polaschegg HD. *In vivo* verification of an automatic non invasive system for real time Kt evaluation. *ASAIO* 39: M348-M352, 1993.
3. Peticlerc T, Bene B, Jacobs C, Jaudon MC, Goux N. Non-invasive monitoring of effective dialysis dose delivered to the haemodialysis patient. *Nephrol Dial Transplant* 10: 212-216, 1995.
4. Lowrie EG, Chertow GM, Lew NL, Lazarus JM, Owen WF. The urea {clearance x dialysis time} product (Kt) as an outcome-based measure of hemodialysis dose. *Kidney Int* 56: 729-737, 1999.
5. Chertow GM, Owen WF, Lazarus JM, Lew NL, Lowrie EG. Exploring the reverse J-shaped curve between urea reduction ratio and mortality. *Kidney Int* 56: 1872-1878, 1999.
6. Lowrie EG, Li Z, Ofsthun NJ, Lazarus JM. The online measurement of hemodialysis dose (Kt): Clinical outcome as a function of body surface area. *Kidney Int* 68: 1344-1354, 2005.
7. Lowrie EG, Li Z, Ofsthun NJ, Lazarus JM. Evaluating a new method to judge dialysis treatment using online measurements of ionic clearance. *Kidney Int* 70: 211-217, 2006.
8. Held PJ, Port FK, Wolfe RA, Stannard DC, Carrol CE, Daugirdas JT, Bloembergen WE, Geer JW, Hakim RM. The dose of hemodialysis and patient mortality. *Kidney Int* 50: 550-556, 1996.
9. NKF-DOQI Hemodialysis Adequacy Work Group Memberchip. Guidelines for hemodialysis adequacy. *Am J Kidney Dis* 30 (Supl. 2): S22-S63, 1997.
10. Maduell F, García M, Alcázar R. Dosificación y adecuación del tratamiento dialítico. Guías SEN: Guías de Centros de hemodiálisis. *Nefrología* 26 (Supl. 8): 15-21, 2006.
11. Depner T, Daugirdas J, Greene T, Allon M, Beck G, Chumlea C, Delmez J, Goth F, Kusek J, Levin N, Macon E, Milford E, Owen W, Star R, Toto R, Eknoyan G. Hemodialysis (HEMO) Study Group: Dialysis dose and the effect of gender and body sike on outcome in the HEMO Study. *Kidney Int* 65: 1386-1394, 2004.
12. Port FK, Wolfe RA, Hulbert-Shearon TE, McCullough KP, Ashby VB, Held PJ. High dialysis dose is associated with lower mortality among woman but not among men. *Am J Kidney Dis* 43: 1014-1023, 2004.
13. European Best Practice Guidelines for Haemodialysis. *Nephrol Dial Transplant* 17 (Supl. 7): 17-21, 2002.
14. The Renal Association. Recommended standards for haemodialysis. Royal College of Physicians of London. Treatment of adult patients with renal failure. *Recommended standards and audit measure* 17-29, 1997.
15. The Canadian Society of Nephrology. Clinical practice guidelines the delivery of haemodialysis. *J Am Soc Nephrol* 10: S306-S310, 1999.
16. De Francisco ALM, Escalada R, Fernández Fresnedo G, Rodrigo E, Setién M, Heras M, Ruiz JC, Arias M: Medida continua de la dosis de diálisis mediante dialisancia iónica. *Nefrología* 18: 408-414, 1998.
17. Holgado R, Martín-Malo A, Álvarez-Lara MA, Rodríguez A, Soriano S, Espinosa M, Aljama P: Estudio comparativo entre dialisancia iónica y el aclaramiento de pequeñas moléculas con diferentes dializadores. *Nefrología* 18: 401-407, 1998.
18. Maduell F, Navarro V, García H, Calvo C. Resultados del seguimiento de la dosis de hemodiálsis en tiempo real y en cada sesión. *Nefrología* 19: 532-537, 1999.
19. Teruel JL, Fernández Lucas M, Marcén R, Rodríguez JR, Rivera M, Liaño F, Ortuño J: Cálculo de la dosis de diálisis mediante dialisancia iónica. *Nefrología* 21: 78-83, 2001.
20. Maduell F, Puchades MJ, Navarro V, Rius A, Torregrosa E, Sánchez JJ. Valoración de la medición de la dosis de diálisis con dialisancia iónica en hemodiafiltración on-line. *Nefrología* 25: 521-526, 2005.
21. Maduell F, Hdez-Jaras J, García H, Calvo C, Navarro V. Seguimiento de la dosis de hemodiálisis en tiempo real. El futuro inmediato. *Nefrología* 17 (Supl. 2): 51, 1997.
22. Teruel JL, Álvarez Rancel LE, Fernández Lucas M, Merino JL, Liaño F, Rivera M, Marcén R, Ortuño J. Control de la dosis de diálisis mediante dialisancia iónica y bioimpedancia. *Nefrología* 27: 68-73, 2007.
23. Barth RH. Direct calculation of KT/V. A simplified approach to monitoring of hemodialysis. *Nephron* 50: 191-195, 1988.
24. Maduell F, Sigüenza F, Caridad A, Miralles F, Serrato F. Analysis of urea distribution volume in hemodialysis. *Nephron* 66: 312-316, 1994.
25. Garred LJ, Rittau M, McCready W, Canaud B. Urea kinetic modelling by partial dialyzate collection. *Int J Artif Organs* 12: 96-102, 1987.