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ORIGINAL ARTICLE

Impact of targeting *Kt* instead of *Kt/V*

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ABSTRACT

Background. Patients must receive an adequate dialysis dose in each hemodialysis (HD) session. Ionic dialysance (ID) enables the dialysis dose to be monitored in each session. The aim of this study was to compare the achievement of *K*t versus *eK*t/*V* values and to analyse the main impediments to reaching the dialysis dose.

Methods. Of 5316 patients from 54 Fresenius Medical Care centers in Spain undergoing their usual HD regime, 3275 received ID and were included in the study.
Results. The minimum prescribed dose of *e*Kt/*V* was reached in 91.2% of the patients, while the minimum recommended dose of *K*t was reached in only 66.8%. Patients not receiving the minimum *K*t dose were older, had spent 7 months less on dialysis, had a dialysis duration of 6 min less, had 5.7 kg more of body weight and Q_b was 47 mL/min lower. The target *K*t was not reached by 62% of patients with catheters and by 37% of women. With each quintile increase of body weight, *e*Kt/*V* decreased and *K*t increased. Of patients with a body weight >80 kg, 1.4%, mostly men, reached the target *K*t but not prescribed *e*Kt/*V*.
Conclusions. The impact of monitoring the dose with *K*t instead of *K*t/*V* is that identifies 25.8% of patients who did not reach the minimum *K*t while achieving *K*t/*V*. The main impediments to achieving an adequate dialysis dose were catheter use, female sex, advanced age, greater body weight, shorter dialysis time and lower Qb.

INTRODUCTION

Traditionally, dialysis dose recommendations are based on monthly analytical determinations, although these determinations are often carried out bimonthly or quarterly. The National Kidney Foundation's haemodialysis (HD) practice guidelines (DOQI) recommend a minimum *K*t/*V* of 1.2 and/or an urea reduction ratio (URR) of 65%. Multiple factors can influence the efficacy of each HD session and consequently, control systems have been created to quantify the dose received by the patient in each session and in real time. Currently, various monitoring systems have incorporated sensors, called online clearance monitoring (OCM) or Diascan, which noninvasively measures the effective ionic dialysance (ID), equivalent to urea clearance (K), by using the machine's own conductivity probes. These sensors enable the dialysis dose to be calculated without additional workload, analytical determinations or cost [1–3].

Systematic determination of K by ID multiplied by the duration of the HD treatment session (T_d or t) allows *K*t to be obtained, a real measure of dialysis dose, expressed in liters. *K*t offers the advantages that both *K* and *t* are real and are measured by the monitor. When *K*t/*V* is used, *V* must be introduced and therefore, a value based on anthropometric formulas (age, gender, body weight and height) or other methods (bioimpedance) must be introduced, hampering evaluation and standardization of *K*t/*V* [4, 5].

In 1999, Lowrie *et al.* [6] proposed *K*t as a marker of dialysis dose and mortality. These authors observed a *J*-shaped survival curve when they distributed the patients into quintiles from the smallest to the highest URR, while the curve descended with *K*t for the same patients [7]. A minimal effective *K*t of 40–45 L for women or 45–50 L for men was recommended. In 2005, the minimum *K*t dose was individualized according to the body surface area (BSA) [8] and was validated in a further study [9].

The ORD (Optimizing Results in Dialysis) Research initiative began in 2010 with the aim of improving HD patient outcomes by elucidating patient characteristics and practising care in Spain [10].

The aim of this study was to compare the achievement of a minimum target *K*t and *e*Kt/*V* ≥1.2, and to explore the factors influencing delivery of an adequate dialysis dose, based on a clinical database from the Spanish Fresenius Medical Care dialysis centers [11].

PATIENTS AND METHODS

In this cross-sectional study, the EuCliD database was analyzed and 54 FMC centers in Spain were included. Of 5316 patients, 3275 (61%) were receiving ID and were included in this study. We compiled all data during 1 month. We recorded their survival status (active, transplanted, transferred, death and others) 1 year later.

The patients were dialyzed with 4008S or 5008 (Fresenius) monitors, equipped with OCM sensors. This device noninvasively measures the effective ID, which is equivalent to urea clearance, using two conductivity probes. A mathematical model consisting of a quadratic equation with two unknown variables, applied to the two dialysate conductivity measures at the inlet and at the outlet of the dialyzer, identifies the effective ID corrected for ultrafiltration and vascular access recirculation.

The prescription of dialysis dose aimed to achieve a minimum *K*t/*V*. In accordance with clinical guidelines [12–14], the minimum target of *e*Kt/*V* was defined as ≥1.2. *e*Kt/*V* was calculated in the same month by routine mid-week blood analysis of pre- and post-dialysis urea, according to the two-compartment Daugirdas formula. We analyzed the extent to which the minimal individualized target *K*t and the minimum target *e*Kt/*V* were achieved.

The minimum target *K*t was calculated for each patient evaluating target *K*t values in terms of BSA based on the analysis of patient survival time tested before in previous studies to determine which best fit the empirical data. The best fit form was a simple algebraic expression that produces a curve increasing with the BSA, such that target *K*t increases more rapidly at low BSA than at high BSA. As a result of this curve, we obtained the *K*t target value from a formula that shows target *K*t in terms of the calculated BSA [8, 9]: minimum target *K*t in liters = 1/[0.0069 + (0.0237/BSA)], with BSA in $m^2 = weight^{0.425} \times height^{0.725} \times 0.007184$, with weight (post-dialysis dry body weight) in kilograms and height in centimeter. Dialysis dose prescriptions aimed to achieve a minimum *K*t/*V* although *K*t was retrospectively analyzed.

The *K*t (between 10 and 14 readings per patient) was assessed at each dialysis session for 1 month to calculate the monthly average received. Achievement of the individual minimum *K*t dialysis dose was defined as a mean delivered *K*t equal to or greater than this target *K*t.

The analysis was performed with the SPSS computer program, version 19. Qualitative variables are shown as percentages and quantitative variables as mean ± standard

deviation. Student's *t*-test, the Mann–Whitney *U*-test or ANOVA were used to compare quantitative variables, in accordance with the categories and types of normal or nonparametric distribution. The chi-squared test was used for qualitative variables. A value of $P < 0.05$ was considered to be statistically significant. Multivariate logistic regression analysis was performed to identify factors predicting the achievement of the minimum target *K*t and/or *eK*t/*V*. Confidence intervals were calculated at 95%.

RESULTS

A total of 43584 ID sessions, 43% conventional HD and 57% online hemodiafiltration, were analyzed in the 3275 patients during the monitoring period. Blood samples for *eK*t/*V* analysis were obtained once during the study for each patient.

The mean age was 67.3 ± 15 years, the mean length of time on an HD program was 45.8 ± 41 months and 63% of all patients were male. The mean body height was 162.1 ± 10 cm, the mean BSA was 1.77 ± 0.27 m^2 and the mean anthropometric Watson volume was 35.5 ± 7.5 L, The etiology of chronic renal failure was diabetes mellitus in 18.7%, nephroangiosclerosis in 13.5%, glomerulonephritis in 10.5%, chronic tubulointerstitial nephropathy in 10.1%, polycystic kidney disease in 7.8%, systemic disease in 3.3%, urological causes in 1.5% and unknown in 34.5%. Each patient received the HD treatment with helixone filters (1.4–1.8 m^2). T_d was 236 ± 15 min, blood flow rate (Qb) was 388 ± 40 mL/min, dialysate flow rate (Q_d) was 513 ± 10 mL/min, and body weight was 69.0 ± 15 kg. Vascular access was through an autologous arteriovenous fistula (AVF) in 2266 patients (69.2%), prosthetic arteriovenous fistula (PTFE) in 134 (4.1%) and venous central catheters (CVCs) in 875 (26.7%).

A mean *eK*t/*V* of 1.57 ± 0.32 was obtained. The minimum *eK*t/*V* target dose of 1.2, which was the initial prescription goal, was achieved in 91.2% of the patients (Figure 1).

When the minimum recommended *K*t dialysis dose was 49.3 ± 4.06 L, the mean delivered *K*t was 52.6 ± 8.80 L. The minimum *K*t dose was achieved in 66.8% of the patients (Figure 1). The difference between the actual liters of *K*t received and the minimum prescribed liters of *K*t ranged from −39 to +30 liters, expressed in deciles (Figure 2).

The main differences in dialysis parameters between patients achieving and not achieving the minimum *K*t dose are shown in Table 1. The determining factors were older age, less time on the dialysis program, shorter sessions and lower Qb. Body weight was also a differentiating factor, with patients reaching target values having a mean of 67.1 ± 14 kg and patients not achieving these values having a mean of 72.8 ± 15 kg.

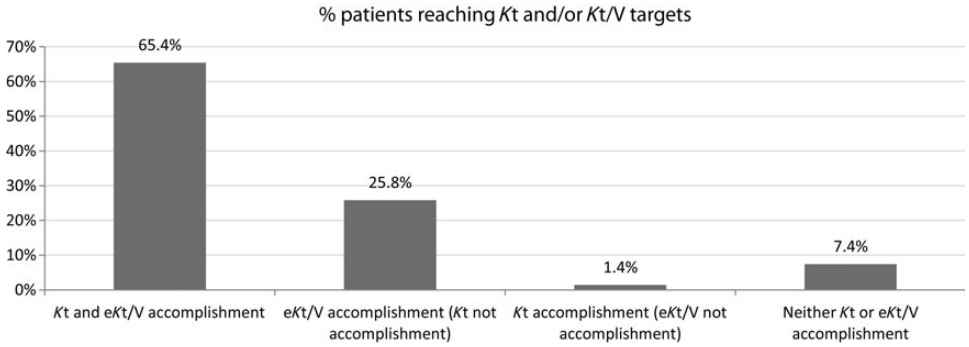

FIGURE 1: Percentage of patients achieving the minimum prescribed *eK*t/*V* and/or *K*t ($n = 3275$).

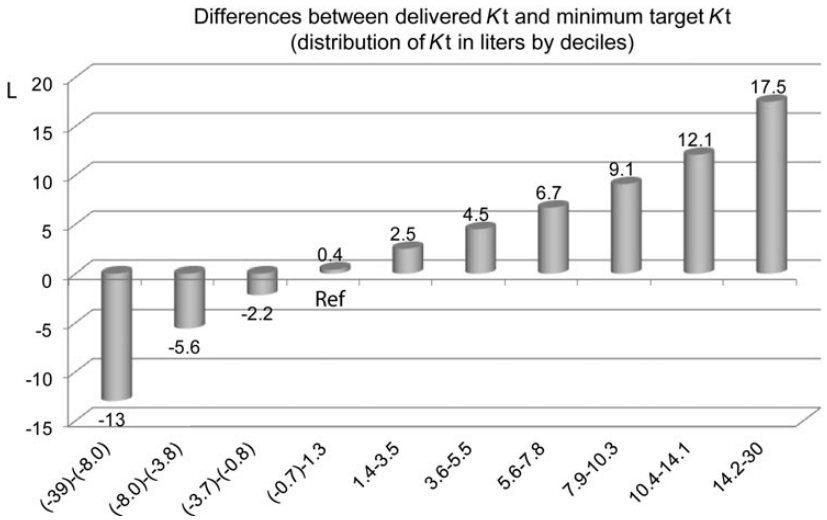

FIGURE 2: Differences between the *K*t administered and the minimum prescribed *K*t (distribution by deciles of liters of *K*t received; $n = 3275$).

Table 1. Differences between patients achieving or not *Kt* adjusted to the BSA

	Kt achieved *n* = 2189 (66.8%)	*Kt* not achieved *n* = 1086 (33.2%)	P-value
eKt/V	1.657 ± 0.30	1.399 ± 0.34	0.000
Kt target (L)	48.9 ± 4	50.3 ± 4	0.000
Kt (L)	56.8 ± 6	44.0 ± 7	0.000
Age (years)	66.6 ± 15	69.1 ± 13	0.000
Months in HD	48.2 ± 43	41.2 ± 37	0.000
T_d (min)	238.1 ± 10	231.8 ± 19	0.000
Q_b (mL/min)	405 ± 47	352 ± 83	0.000
Q_d (mL/min)	512 ± 62	514 ± 64	NS
Filter area (m^2)	1.43 ± 0.11	1.44 ± 0.13	0.007
K_OA urea (mL/min)	1002 ± 86	1011 ± 99	0.006
Post-HD weight (kg)	67.1 ± 14	72.8 ± 15	0.000
Height (cm)	162.2 ± 10	162.1 ± 10	NS
BSA (m^2)	1.75 ± 0.21	1.83 ± 0.21	0.006
Vol. Dist. Urea Watson (L)	35.05 ± 6.19	36.30 ± 6.35	NS

Analysis of body weight and division of the population into quintiles of body weight showed an inverse relation between *eKt/V* and body weight. However, this relation was direct between *Kt* and body weight (Figure 3). The degree of *eKt/V* and *Kt* achievement gradually reduced as body weight increased, the only exception being patients in the lowest quintile of body weight, who were less likely to achieve the minimum *Kt* dose than were patients in the quintile immediately above.

The minimum *Kt* dose was reached in fewer women (63%) than men (69%), even though the value was lower (45.58 ± 4.0 in women versus 50.37 ± 3.7 in men; P < 0.001). Table 2 examines gender differences for the prescribed dialysis parameters. Compared with men, women were older, had a shorter T_d, lower Q_b and Q_d, and had a lower body weight.

The type of vascular access had a clear influence on the dialysis dose. The minimum dose was less frequently achieved in patients dialyzed with a CVC (38%) than in those dialyzed with an AVF and PTFE (77%), even though the minimum prescription of *Kt* and the body weight were lower (Table 3). Patients with a CVC were older and had a lower Qb.

To analyze the discrepancies between *eKt/V* and *Kt*, we compared the 2142 (65.4%) patients who achieved both criteria with those who achieved only one of the criteria or neither of them (Table 4). In 845 patients (25.8%), the target *eKt/V* was achieved but not the target *Kt*. In these patients, body weight was significantly higher and *Kt* was lower. In this group, there was also a significantly higher percentage of women (45.6 versus 36%), T_d was 5 min shorter and Q_b was 49 mL/min lower. Catheter use was also significantly higher (48 versus 15%). After logistic regression and risk analysis in the groups of patients not achieving the minimum *Kt*, we observed that older age, higher body weight and catheter as vascular access represent a risk of not accomplishing the *Kt* target. In contrast, prolonging the length of the HD session increased the probability of reaching target *Kt* (Table 5).

Kt, but not *eKt/V*, was achieved in 47 patients (1.4%). Importantly, this small group mainly consisted of men (93.4%) with a higher body weight (increase of 19.2 kg). Compared with patients who achieved both criteria (Table 4), in this group, dialysis duration and Qb were similar, but Q_d was slightly higher. The percentage of patients with a CVC was only 8.5%. The logistic regression analysis showed that women achieved an *eKt/V* target value four times more than men. Higher body weight increases the risk of not raising *eKt/V* objectives. In contrast, longer dialysis time increased the probability of reaching the minimum *eKt/V* target (Table 5).

Neither *eKt/V* nor *Kt* was achieved in 7.35%. In this group, CVCs were used in more than half (57.7%), body weight was 11.6 kg higher, 24% were women and T_d and Q_b were lower (Table 4). Logistic regression showed that body weight reduced the possibility of reaching both *eKt/V* and *Kt*. Catheter use reduced the probability of reaching both *eKt/V* and *Kt* by 58%, while the dialysis duration improved the probability of reaching target levels% (Table 5).

One year follow-up after the end of the study reveals 9% mortality in *Kt* accomplishment patients versus 11% in *eKt/V* accomplishment patients, but we will need deeper survival analysis to relate morbidity and mortality to *Kt* or *eKt/V* accomplishment.

DISCUSSION

This study describes the impact of the use of *Kt* instead of *Kt/V*. The differences in other methods lie in dose determination, expression of *Kt* in liters and exhaustive monitoring of all dialysis sessions. Compared with the usual analytical recommendations for *eKt/V*, the greatest challenge is that a third of the patients did not achieve the minimum *Kt* dose, while only 9% of patients failed to reach the target *eKt/V*. This study allowed us to analyze the characteristics of the patients not achieving the minimum target *eKt/V* or *Kt*, or both, compared with those that reached both minimum dialysis doses. The determining factors for under-dialysis were CVC use, female sex and higher body weight. Individualizing the dialysis parameters (essentially T_d and Q_b) to the patient characteristics

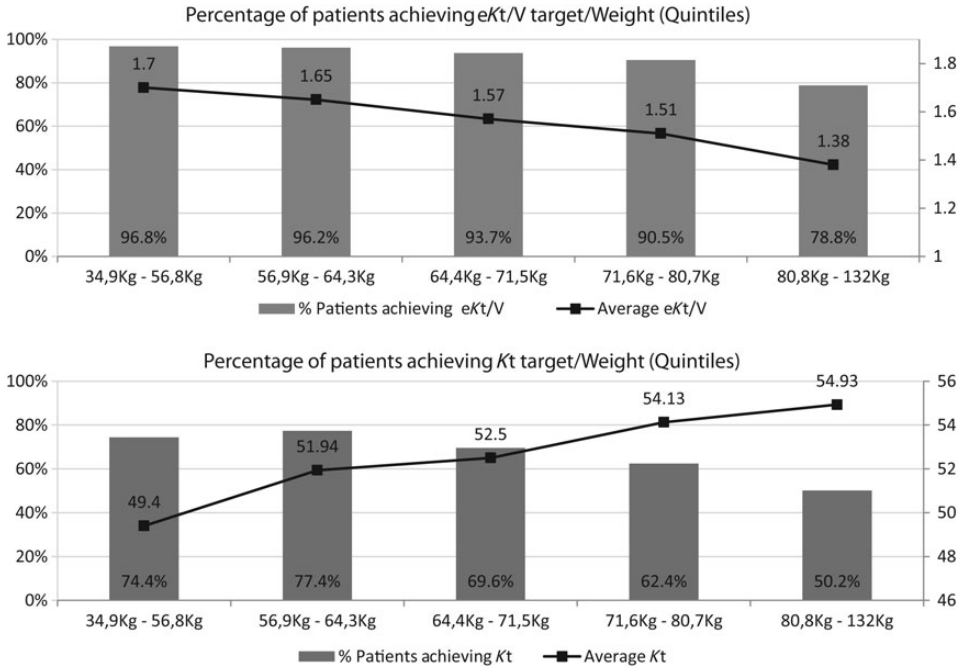

FIGURE 3: Percentage of patients achieving *K*t or *eK*t/*V* target dose according to weight quintile $n = 3275$).

Table 2. Influence of gender over HD doses and dialysis parameters

	Men $n = 2066$ (63.1%)	Women $n = 1209$ (36.9%)	P-value
*eK*t/*V* target	1.2	1.2	
*eK*t/*V* achieved	1.50 ± 0.29	1.71 ± 0.01	0.000
% Pt. *eKtV* achieved	1149 (95%)	1838 (89%)	0.000
*K*t target (L)	50.37 ± 3.71	45.58 ± 4.03	0.000
*K*t achieved (L)	53.98 ± 8.70	50.30 ± 8.43	0.000
% Pt. *K*t achieved	1422 (69%)	767 (63%)	0.001
Age (Years)	66.39 ± 15.02	69.02 ± 14.24	0.000
Months in HD	44.04 ± 39.36	49.08 ± 43.8	0.000
T_d (min)	237.61 ± 13.46	233.55 ± 14.48	0.002
Q_b (mL/min)	394.84 ± 71.93	376.35 ± 52.78	0.000
Q_d (mL/min)	516.28 67.95	506.98 46.29	0.000
Filter area (m^2)	1.44 ± 0.13	1.41 ± 0.076	0.000
K_OA urea (mL/min)	1015 ± 102	990 ± 62	0.000
Post-HD weight (kg)	71.83 ± 13.73	65.11 ± 14.55	0.000
Height (cm)	166.6 ± 9.0	154.5 ± 7.7	0.000
BSA (m^2)	1.83 ± 0.20	1.6 ± 0.21	0.000
Vol. Dist. Urea Watson (L)	38.39 ± 5.51	30.46 ± 3.91	0.000

(mainly gender, body weight and vascular access) is required to ensure the appropriate dialysis dose.

Current dialysis dose recommendations are based on monthly analytical determinations, although these determinations are often carried out bimonthly or quarterly. The National Kidney Foundation's HD practice guidelines (DOQI) recommend a minimum *K*t/*V* of 1.2 and/or an URR of 65%. However, these guidelines recommend a *K*t/*V* of 1.3 and a URR of 70% to ensure that these minimum requirements are reached [13]. The same recommendations can also

Table 3. Impact of vascular access on dialysis dose and HD parameters

	AVF or PTFE $n = 2398$ (73.3%)	Catheter $n = 877$ (26.7%)	P-value
eKt/V	1.60 ± 0.30	1.51 ± 0.38	0.000
Kt target(L)	49.62 ± 4.01	48.56 ± 4.09	0.000
Kt achieved (L)	54.92 ± 7.83	46.23 ± 8.07	0.000
% Pt. *Kt* achieved	1851 (77%)	331(38%)	0.000
Age (years)	66.19 ± 14.92	70.66 ± 13.90	0.000
Months in HD	46.56 ± 40.92	44.28 ± 42	0.024
T_d (min)	236.56 ± 12.71	234.84 ± 16.98	NS
Q_b (mL/min)	406.42 ± 44.30	337.11 ± 86.60	0.000
Q_d (mL/min)	513.12 ± 61.87	512.36 ± 59.38	NS
Filter area (m^2)	1.43 ± 0.11	1.43 ± 0.11	NS
K_OA urea (mL/min)	1005 ± 90	1007 ± 93	NS
Post-HD weight (kg)	70.06 ± 14.33	67.37 ± 14.33	0.000
Height (cm)	163.3 ± 10	158.9 ± 10	0.000
BSA (m^2)	1.79 ± 0.22	1.73 ± 0.22	0.000
Vol. Dist. Urea Watson (L)	36.12 ± 6.33	33.66 ± 5.74	0.000

be found in the European Guidelines [15], the Canadian Guidelines [16], the UK Guidelines [17] and the Guidelines of the Spanish Society of Nephrology [14]. If determinations are only carried out monthly, bimonthly or quarterly to calculate the dialysis dose, the results of these 4, 6 or 12 readings (3 to 7% of the sessions) will be extrapolated to everything that occurs in the 156 annual sessions. Because multiple factors can influence dialytic efficacy in each HD session, control systems have been developed to quantify the dose received by the patient in each session and in real time. Most monitors have incorporated ID, which allows the dialysis dose to be calculated in all sessions, without involving additional workload, analytical determinations or cost. Consequently, many dialysis units have already abandoned pre- and post-dialysis urea determinations. However, a post-dialysis monthly blood sample is recommended to calculate other parameters of the urea kinetic model, such as the protein catabolic rate, as well as to adequately monitor electrolytes and bicarbonates.

Using *Kt* offers several advantages. Both *K* and t are real-time monitor readings, which cannot be manipulated by the user and can be used in all dialysis sessions at no additional cost. The *J*-shaped survival curve, which occurs when patients are distributed into quintiles according to the URR or *Kt/V* [7], is avoided (patients who appear to be receiving a higher dialysis dose when the *Kt/V* or URR is measured could be considered as under dialysis if *Kt* is considered). The initial 1999 recommendations were made according to gender [6] and were individualized in 2005 according to the BSA [8]. These indications were validated [9]; a *Kt* of between 4 and 7 L less than the prescribed dose increases mortality by 10%, between 7 and 11 L less would lead to a 25% increase and ≥11 L less would increase mortality by over 30%. In this study, we found that the recommended dose was achieved in 91% of patients when classical *eKt/V* prescriptions were used, while only 67% did so if *Kt* alone was used.

Various studies that have used ID in HD and that have expressed ID as *Kt/V* have concluded that *Kt/V* readings through ID differ from analytical readings, although the correlation between both procedures is good [18, 19], being equal to that in hemodiafiltration [20], which demonstrates variability between the methods used. To obtain *Kt/V*, *V* must be introduced, an inaccurate value, which can be obtained by anthropometrical equations such as Watson's, by calculating the measured *Kt* divided by the analytical *Kt/V* or by bioimpedanciometry [21]. *Kt/V* determined by ID is normally underestimated compared with *Kt/V* calculated by the second-generation Daugirdas formula obtained by analysis [18, 19, 22, 23].

Several studies have shown that the general *Kt/V* recommendations could lead to underdialysis in women. In a later analysis in the HEMO study, increasing the dialysis dose in a subgroup of women reduced mortality by 19% [24]. The same conclusion was observed by Port *et al.* [25] in 74 120 patients in the USA and in 10 816 patients in seven countries taking part in the DOPPS study. Based on these studies, Spanish guidelines [14] now recommend that women should receive a *Kt/V* dose >1.6. As shown by our results, achieving *eKtV* is influenced by gender, women being the group achieving the highest *eKt/V*. However, when *Kt* is chosen as the dialysis dose indicator, this difference disappears (Table 5). We found that achievement of *Kt* recommendations was 6% lower in women, especially in women who reached the target e*Kt/V* but not the target *Kt*. This could be an explanation for higher under-dialysis in women.

Table 4. Comparison between *Kt/Ve* and *Kt* compliant patients versus those *eKt/V*, *Kt* or both non-compliant patients

	Achieved *eKt/V* Achieved *Kt* *n* = 2142 (65.4%)	Achieved *eKt/V* not achieved *Kt* *n* = 845 (25.8%)	P-value	Not achieved *eKt/V* Achieved *Kt* *n* = 47 (1.43%)	P-value	Not achieved *eKt/V* not achieved *Kt* *n* = 241 (7.35%)	P-value
eKt/V	1.68 ± 0.27	1.51 ± 0.26	0.000	1.12 ± 0.80	0.000	1.00 ± 0.26	0.000
Kt target (L)	48.74 ± 3.89	49.83 ± 4.07	0.000	54.01 ± 3.26	0.000	51.90 ± 4.01	0.000
Kt achieved (L)	56.80 ± 6.29	44.53 ± 6.07	0.000	58.93 ± 5.24	NS	42.16 ± 8.03	0.000
Gender (% Fem)	36%	45.6%	0.000	6.4%	0.000	23.7%	0.000
Age (years)	66.81 ± 15.2	69.92 ± 13.2	0.000	58.61 ± 15.6	0.001	66.15 ± 13.9	NS
Months in HD	48.6 ± 3.60	43.2 ± 37.2	0.003	29.16 ± 23.88	0.008	33.72 ± 33.96	0.000
T_d (min)	238.07 ± 9.8	233.40 ± 15.6	0.000	241.8 ± 38.8	NS	226.1 ± 28.4	0.000
Q_b (mL/min)	406 ± 47	357 ± 88	0.000	403 ± 47	NS	336 ± 59	0.000
Q_d (mL/min)	512 ± 60	512 ± 58	NS	542 ± 100	0.027	524 ± 82	0.047
Filter area (m^2)	1.42 ± 0.11	1.43 ± 0.12	NS	1.42 ± 0.11	0.003	1.46 ± 0.18	0.001
KOA urea (mL/min)	1001.2 ± 84.0	1006.8 ± 92.51	NS	1049 ± 133.79	0.002	1006.8 ± 92.5	0.000
Post-HD weight (kg)	67.06 ± 13.4	71.62 ± 14.6	0.000	86.29 ± 14.2	0.000	78.68 ± 15.6	0.000
AV (% catheter)	15.3%	48%	0.000	8.5%	0.000	57.7%	0.000
Height (cm)	162.0 ± 10.3	161.0 ± 9.7	NS	169 .9 ± 11.7	0.000	165.7 ± 10.6	0.000
BSA (m^2)	1.74 ± 0.20	1.80 ± 0.22	0.000	2.03 ± 0.20	0.000	1.92 ± 0.22	0.000
V Watson (L)	34.85 ± 6.05	35.42 ± 6.03	NS	43.77 ± 6.54	0.000	39.38 ± 6.50	0.000

Spalding *et al.* [26] reports that *Kt/V* could underestimate the dose in women, as well as in small men, highlighting the importance of the patient's body weight and the inverse behavior with the dose expressed as *Kt/V* or *Kt*. Based on the argument that there are various physiological variables scaled allometrically with respect to body size in the animal kingdom, Singer and Morton's group [27, 28] emphasize that both the glomerular filtration rate and the basal metabolic rate in mammals are scaled according to body weight with an almost identical exponent. Therefore, increasing the dialysis dose in those patients with a lower body weight should be considered. Our results support this explanation, target *Kt* was not achieved in a higher percentage of patients in the lowest body weight quintile, although these patients received the highest *Kt/V*. In contrast, the small group of patients (<2% and mainly men over 85 kg) who reached the minimum *Kt* but not the minimum *Kt/V* should be considered as receiving a correct dose.

Finally, the risk of under-dialysis increased in patients with CVCs. In European countries, the use of tunneled CVC has gradually increased as a permanent form of vascular access [29]. Although the blood flow (Qb) obtained with tunnelled catheters is increasingly higher, the dialysis doses reached remain even lower than those obtained by native AVFs or vascular prostheses. Due to the high variability of doses between HD sessions when using a catheter, the ideal solution would be to generalize monitor use with ID and incorporate *Kt* determination into each session to guarantee an adequate minimum dose. According to a previous study [30], when monitors are not available for monitoring *Kt*, the HD time should be increased, on average, by 30 min if a catheter is used in the normal position and by 60 min if the catheter is in an inverted position. In the present study, only 38% of the patients with a CVC reached the minimum *Kt*. Similarly, of the patients who did not reach *Kt* but did reach t*Kt/V* or did not reach either, those with CVCs represented 48 and 58%, respectively. The use of the ID also allows an estimation of access recirculation through the ID/blood flow rate ratio [31, 32].

Table 5. Multivariate logistic regression

	Kt non-accomplishment		*eKt/V* non-accomplishment		*Kt* and *eKt/V* non-accomplishment	
	OR (IC 95%)	P-value	OR (IC 95%)	P-value	OR (IC 95%)	P-value
Age (years)	1.01 (1.003–1.018)	0.003	0.98 (0.979–0.999)	0.036	NS	NS
Gender male (Ref:Fem)	NS	NS	3.70 (2.595–5.300)	0.000	3.60 (2.45–5.28)	0.000
Time in HD (years)	NS	NS	0.93 (0.882–0.980)	0.007	0.94 (0.88–0.99)	0.041
Q_b (mL/min)	0.97 (0.968–0.974)	0.000	0.98 (0.977–0.983)	0.000	0.97 (0.97–0.99)	0.000
Catheter (Ref: FAVi)	1.66 (1.297–2.127)	0.000	NS	NS	1.58 (1.05–2.38)	0.028
HD session time	0.93 (0.929–0.945)	0.000	0.95 (0.942–0.958)	0.000	0.94 (0.93–0.95)	0.000
Post-HD weight (kg)	1.08 (1.073–1.090)	0.000	1.08 (1.069–1.092)	0.000	1.07 (1.06–1.09)	0.000

Parameters predicting *Kt* and/or *eKt/V* Non-accomplishment ($N = 3275$).
Logistic regression adjusted to: age, gender, time in HD, Q_b, vascular access, effective time HD session and post-HD weight. NS, Non-significant differences.

In 2008, Daugirdas *et al.* [33, 34] proposed rescaling standard *Kt/V* to BSA as an alternative to *Kt/V* or std*Kt/V* which might allow better quantification of dialysis for both men and women. To calculate the surface area, normalized std*Kt/V* is needed to have pre- and post-urea, sp*Kt/V*, *eKt/V*, std*Kt/V*, anthropometric V formula, BSA, adequate ratio delivered std*Kt/V* and S-normalized minimum target std*Kt/V*. In 2010, Basile *et al.* [35] compared alternative methods for scaling the dialysis dose instead of *V* ($W^{0.67}$, BSA, resting energy expenditure, high metabolic rate organ mass, liver size and bioelectrical resistance). The implementation of this methodology has not been incorporated into clinical practice probably because of the difficulty in understanding and making the appropriate calculations. However, the use of *Kt* seems easy because it is provided directly by the monitor and only it is needed to check if minimum target *Kt* is reached. Nowaday, the only current reference is the study of Lowrie *et al.* with recommendations to set minimum *Kt* adjusted to BSA [8], which are different for different BSA in a non-linear relationship.

Like all treatments, the dialysis dose should be adequately prescribed. Achieving a minimum dialysis dose is the responsibility of nephrologists and is an area that could be improved. Because age, gender and comorbidity cannot be changed, prescription should be adjusted to the dialysis parameters and treatment should be adapted to ensure that the prescribed schedule is received by the patient and inadequate treatment is avoided.

In conclusion, the advantage of monitoring the dose with *Kt* instead *Kt/V* is that this method identifies 25.8% of patients who did not reach the minimum *Kt* while achieving *Kt/V*. This difference is particularly evident in women, in patients with a low body weight, and in those with venous central catheters. The routine use of *Kt* is recommended in all patients who are routinely dialyzed with ID monitors. Although there is still a lack of scientific evidence on the use of *Kt*, now seems the right time to prepare for a change. The percentage of HD machines providing *Kt* has increased in the last few years and could probably reach nearly 100% in the next few years. Therefore, the time is ripe for studies such as our own to rethink dose monitoring and for prospective studies to define and validate the minimum *Kt* recommendations.

CONFLICT OF INTEREST STATEMENT

R.R., I.P., A.G. and J.I.M. are employees of Fresenius Medical Care. None of the other authors have any financial or proprietary interest in the devices or products used in this study.

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