NEFROLOGÍA. Volumen 26. Número 4. 2006

Temperature of the dialysis bath and hemodialysis tolerance

J. L. Teruel, J. Martins, J. L. Merino, M. Fernández Lucas, M. Rivera, R. Marcén C. Quereda and J. Ortuño
Nephrology Department. Ramón y Cajal Hospital. Madrid.

SUMMARY

In this study, the effect of dialysate temperature on hemodynamic stability, patients' perception of dialysis discomfort and postdialysis fatigue were assessed. Thirty-one patients of the morning shift were eligible to participate in the study. Three patients refused. Patients were assessed during 6 dialysis sessions: in three sessions the dialysate temperature was normal (37 ºC) and in other three sessions the dialysate temperature was low (35,5 ºC). To evaluate the symptoms along the dialysis procedure and the postdialysis fatigue, specific scale questionnaires were administered in each dialysis session and respective scores were elaborated.

Low temperature dialysate was associated with higher postdialysis systolic blood pressure (122 ± 24 vs *126 ± 27 mmHg, p < 0,05), and lower postdialysis heart rate (82 ± 13* vs *78 ± 9 beats/min, p < 0,05) with the same ultrafiltration rate. Dialysis symptoms score and postdialysis fatigue score were better with the low dialysate temperature (0,7 ± 0,9* vs *0,4 ± 1* vs *p < 0,05, and 1,3 ± 1* vs *1 ± 0,9 p < 0,05, respectively). Furthermore, low temperature dialysate shortened the postdialysis fatigue period (5,4 ± 6,3* vs *3,1 ± 3,3* vs *hours, p < 0,05).*

The clinical improvement experimented with the low temperature dialysate was not universal. A beneficial effect was exclusively observed in the patients with higher dialysis symptoms and postdialysis fatigue scores or having more than one episode of hypotension in a week.

The patients were asked about their temperature preference, 7 patients (23%) request a dialysate at 37 ºC, 19 patients (61%) prefered to be dialysed with the low temperature dialysate, and 5 patients (16%) were indifferent. The later two groups of the patients continued with the low temperature dialysate during other 4 weeks. At the end of that period, the clinical improvement remained unchanged.

In summary, low temperature dialysate is particularly beneficial for highly symptomatic patients.

Key words: ***Hemodialysis. Low temperature dialysate. Hypotension. Postdialysis fatigue.***

TEMPERATURA DEL BAÑO Y TOLERANCIA A LA HEMODIÁLISIS

En el presente trabajo estudiamos la repercusión de la temperatura del baño sobre la estabilidad hemodinámica en la hemodiálisis actual. También analizamos

Correspondencia: Dr. J. L. Teruel
Servicio de Nefrología
Hospital Ramón y Cajal
Carretera de Colmenar, km 9,100
28034 Madrid

su influencia en la percepción del enfermo de la calidad de la diálisis valorada a través de un índice de valoración subjetiva de la sintomatología en hemodiálisis (ISHD), y en el síndrome de fatiga postdiálisis valorado mediante un índice de sintomatología posthemodiálisis (ISpostHD) y el tiempo de recuperación del mismo (TRpostHD).

Hemos incluido a 31 enfermos clínicamente estables (13 varones y 18 mujeres) cuyo único criterio de selección fue que se dializaban en turno de mañana. El estudio ha sido realizado en dos semanas: en la primera semana los enfermos se dializaron con su temperatura de baño habitual (37 °C) y en la segunda semana se bajó la temperatura del baño a 35,5 ºC.

Al reducir la temperatura del baño hemos objetivado un aumento de la tensión arterial postdiálisis (122 ± 24 vs *126 ± 27 mmHg, p < 0,05) y una disminución de la frecuencia cardíaca postdiálisis (82 ± 13* vs *78 ± 9 latidos/min, p < 0,05), con la misma tasa de ultrafiltración. También disminuyó el ISHD (0,7 ± 0,9* vs *0,4 ± 1, p < 0,05), el ISpostHD (1,3 ± 1* vs *1 ± 0,9, p < 0,05) y el TRpostHD (5,4 ± 6,3* vs *3,1 ± 3,3 horas, p < 0,05).*

El beneficio clínico obtenido con una temperatura baja de baño no fue universal, sino que fue exclusivo de los enfermos que mostraron una peor tolerancia clínica con la temperatura habitual de baño o que tuvieron más de un episodio de hipotensión a la semana. En los restantes enfermos no se observó ninguna mejoría, incluso empeoró el ISHD.

Al finalizar la segunda semana del estudio se les preguntó a los enfermos qué temperatura de baño preferían: siete enfermos (23%) mostraron preferencia por la temperatura de 37 ºC, diecinueve enfermos (61%) por la temperatura de 35,5 ºC, y a los 5 enfermos restantes (16%) les resultaba indiferente. A los enfermos de los dos últimos grupos se les continuó dializando con temperatura baja de baño durante 4 semanas. Dos enfermos solicitaron volver a la temperatura de baño de 37 ºC; en los 22 enfermos restantes persistió la mejoría clínica tras cinco semanas de diálisis con temperatura baja.

Podemos concluir que la temperatura del baño sigue ejerciendo una influencia relevante en la tolerancia de la hemodiálisis. La reducción de la temperatura disminuye tanto la sintomatología durante la sesión de hemodiálisis como el síndrome de fatiga postdiálisis. La mejoría no es universal y por tanto no se trata de una medida para aplicar de forma generalizada. La hemodiálisis con temperatura baja está especialmente indicada en los enfermos con mala tolerancia a la temperatura habitual de 37 ºC.

Palabras clave: ***Hemodiálisis. Temperatura de baño. Hipotensión. Tolerancia a la hemodiálisis. Síndrome de fatiga postdiálisis.***

INTRODUCTION

At the beginning of the 1980s, several studies suggested that decreasing the temperature of the dialysis bath improved the tolerance to the hemodialysis session[1,2]. We could verify this beneficial effect on patients with a high hypotension index[3-5]. These studies were performed before the introduction of erythropoietin in patients that were using acetate baths, monitors with no volumetric monitoring, and cuprophan membrane dialyzers. Advances achieved in hemodialysis technique reduced the interest in temperature of the dialysis bath, and a temperature of 37º C was set as the usual bath temperature[6].

Does temperature reduction of the dialysis bath have any benefit when using a hemodialysis with bicarbonate bath, strict control of the ultrafiltration volume, possibility of using different bath conductivities, biocompatible membranes, and better anemia management? In order to answer to this question, we have design the following study in which we analyze the impact of bath temperature on hemodynamic stability with current hemodialysis. We also tried to know the influence of the temperature on patient's perception of dialysis quality and on the post-dialysis fatigue syndrome. The study carried out on a non-selected population of patients compares the response to two bath temperatures: 37 ºC as the usual temperature, and 35.5º C as a low temperature. We have chosen this latter temperature because several works have shown to be the one producing the least variations in core body temperature[7-10].

MATERIAL AND METHODS

The initial design was to evaluate all patients of the Hemodialysis Unit having dialysis during the morning shift (34 patients). Three patients were excluded from the beginning: two because they had an intercurrent condition (infection of the intravenous catheter, and cerebral ischemic illness), and the third one because of his own decision. The study was done on 31 patients clinically stable that gave their informed consent to participate. They are 13 male and 18 female patients, with ages ranging 28-82 years (66 ± 13, mean and SD), and dialysis therapy duration ranging 5-240 months (41 ± 40). The etiology of renal failure was chronic glomerulonephritis (5 patients), vascular nephropathy (6), diabetic nephropathy (9), interstitial chronic nephropathy (4), unknown cause (4), and other etiologies (3). The vascular access was through a native arteriovenous fistula (26 patients), and a permanent jugular catheter (5).

Patients had dialysis three times a week, in 3-4 hour sessions, with a pump arterial blood flow of 300-400 mL/min, and flow of the dialysis bath of 500 mL/min. The dialysis bath was with bicarbonate with a calcium concentration of 2.5 mEq/L. In sixteen patients the total bath conductivity was 14 mS/cm, in 9 patients 14.5 mS/cm, and 6 patients had a decreasing conductivity profile (initial 15 mS/cm, final 14 mS/cm), and ultrafiltration (initial 1.6 L/h, final 0.1 L/h). All patients used hollow fiber dialyzers with high-permeability biocompatible membrane: AN69 of 1.65 m^2 (7 patients), polyamide of 2.1 m^2 (5), polysulphone of 1.8 m^2 (6) and poly aril ether sulphone of 2.1 m^2 (13), with ultrafiltration coefficients of 50, 83, 59 and 27.1 mL/(h x mmHg), respectively.

The dialysis technique was conventional hemodialysis, no patient being treated with hemodiafiltration. The hemodialysis session conditions were kept stable throughout the study.

Integra® (Hospal) monitors were used with volumetric control of ultrafiltration, in an air-conditioned room with stable temperature at 22 ºC. Previous temperature of the dialysis bath of all patients was 37 ºC. Before the onset of the study, the thermostat set of the monitors was checked at 35.5 ºC and 37º C, with an error margin of ± 0.1 ºC.

The 31 patients received erythropoietin, and at the beginning of the study hemoglobin concentration ranged between 9.9-13.2 g/dL (mean 11.8, median 11.9).

Blood pressure, heart rate, and temperature at the axilla were determined before puncturing the arteriovenous fistula or the jugular catheter connection (predialysis values), and five minutes after having disconnected the needles or sealed the catheter with heparin, whichever was indicated (post-dialysis values). Blood pressure was determined with a digital electronic sphingomanometer with the patient on sitting position, and axillary temperature with a mercury thermometer with glass support. In patients carrying an arteriovenous fistula, the contralateral arm was used for both BP measurements.

The study was done throughout two consecutive weeks. During the first one, patients continued having their dialysis with the usual bath temperature at 37 ºC, the data of this week were considered as baseline values; during the following week, the bath temperature was decreased to 35.5 ºC. During the study weeks, pre- and post-dialysis blood pressure, heart rate, and axillary temperature values were determined, as well as the ultrafiltration rate of each dialysis session (expressed in mL and in percentage of lean weight). The average value of the three weekly values was calculated for each patient. The number of hypotension events that patients had during the three sessions along the week (HE, total of episodes/week) and the different symptoms and complications that they might have presented were registered. Hypertension was considered if a patient had a prescription of antihypertensive drugs or when three determinations of pre-dialysis BP during the first week of the study were ≥ 150/90 mmHg. According to this criterion, 12 patients were hypertensive, 11 of which were on antihypertensive medication (a calcium channel blocker in 5 patients, a beta-blocker in 4 patients, and an angiotensin receptor antagonist-II in the remaining 2 patients). A hypotension event was defined according to the criterion established by the DOQI guidelines: a decrease in systolic BP ≥ 20 mmHg associated with symptoms[11]. Hypotension episodes were treated by infusion of physiologic saline.

To assess the patients' perception on the symptoms they had during the hemodialysis session we used a modification of the questionnaire designed by Cruz *et al.*[12] At the end of each dialysis session during the study weeks, a questionnaire was passed to each patient with the following questions: Have you had any discomfort during the dialysis session? Which one? What level of discomfort have you noticed? If the patient recovered rapidly, the discomfort was considered as being mild, if it persisted for longer than half an hour it was considered moderate, and if it persisted throughout the whole session it was considered as severe.

Further, a numerical value was assigned: 0 if the session was perceived as without symptoms; and 1, 2, or 3 if the discomfort was mild, moderate, or severe, respectively. The mean of the three values of the week made up the hemodialysis symptomatology index (HDSI) for each patient.

To assess the post-dialysis fatigue syndrome we used the modified Sklar *et al.*[13] questionnaire. Before each dialysis session the patient was asked: How long did it take to recover from the last dialysis session? Which was the main complaint he/she had? What level of discomfort did he/she experienced? The discomfort was considered mild if it did not prevent the patient from doing his/her usual activity, moderate if his/her activity was limited but he/she did not have to bed-rest, or severe if he/she had to bed-rest to recover. A numerical value was also assigned: 0 if there was no post-dialysis syndrome; 1, 2, or 3 if the discomfort was mild, moderate, or severe, respectively. The post-hemodialysis symptomatology index (SIpostHD) for each patient was the mean of the three values of the week. The recovery time from the postdialysis syndrome was determined in hours (a 0 value was assigned if there was no postdialysis syndrome), and the weekly average was calculated for each patient.

At the end of the second study week, each patient was asked what bath temperature did he/she preferred: normal (37 ºC) or low (35.5 ºC). Next, and for the following four weeks, each patient was dialyzed using his/her preferred temperature, and during the last week all the previous parameters were gathered once again including the corresponding questionnaires. All questionnaires were taken by the same individual (JM).

During the 6 weeks that the study lasted, in two occasions the endotoxin activity in the dialysis water was determined (LAL test), and in both occasions it was below 0.05 IU/mL.

All the results are expressed as mean and SD. For the statistical analysis, the Student's t test was used for both paired and non-paired data. P values < 0.05 were considered as statistically significant.

RESULTS

The results of axillary temperature, systolic blood pressure (SBP), diastolic BP (DBP), heart rate, hypotension events, and subjective assessment indexes of symptomatology during hemodialysis, post-hemodialysis syndrome, and recovery time, by bath temperature are shown in table I. When compared to predialysis values, post-dialysis axillary temperature was not changed with the dialysis bath at 37 ºC, but it decreased with the bath at 35.5 ºC ($p < 0.001$). Blood pressure decreased after dialysis with both bath temperatures ($p < 0.05$ for SBP with both temperatures, $p < 0.05$ for DBP at 37º C, and $p = 0.07$ for DBP at 35.5º C). Heart rate increased with bath temperature at 37 ºC ($p < 0.01$) and was not changed with temperature bath at 35.5 ºC. We did not observe any differences in ultrafiltration rates: 2.278 ± 697 mL (3.6 ± 1.2% of lean weight) with dialysis bath at 37 ºC, and 2.327 ± 695 mL (3.6 ± 1% of lean weight) with bath at 35.5 ºC.

The main discomfort referred by the patients during the hemodialysis session was lightheadedness; this symptom being the one that most conditioned the HDSI. Other reported symptoms were: with bath temperature at 37 ºC, three patients reported heat feeling and discomfort, and one cramps. With bath temperature at 35.5 ºC, four patients had chills, and four pa-

Table I. Evolution of clinical parameters by decreasing the dialysis bath temperature

	Bath temperature		
	37 °C	**35,5 °C**	
Pre-dialysis temp.	36 ± 0.4	36.1 ± 0.3	
Postdialysis temp.	36 ± 0.4	35.8 ± 0.3	
Pre-dialysis SBP	131 ± 24	131 ± 28	
Postdialysis SBP	122 ± 24	126 ± 27	p < 0.05
Pre-dialysis DBP	73 ± 13	74 ± 14	
Postdialysis DBP	70 ± 13	71 ± 13	
Pre-dialysis HR	76 ± 9	79 ± 9	
Postdialysis HR	82 ± 13	78 ± 9	p < 0.05
HE	1.2 ± 1.7	0.9 ± 1.3	
HDSI	0.7 ± 0.9	0.4 ± 1	p < 0.05
SIpostHD	1.3 ± 1	1 ± 0.9	p < 0.05
RTpostHD	5.4 ± 6.3	3.1 ± 3.3	p < 0.05

Temp: temperature at the axilla (°C); SBP: systolic blood pressure (mmHg); DBP: diastolic blood pressure (mmHg); HR: heart rate (beats per minute); HE: hypotensive events during dialysis (events/week); HDSI: Symptomatology index during hemodialysis; SIpostHD: Symptomatology index post-hemodialysis; RTpostHD: recovery time from postdialysis symptomatology (hours).

tients had cramps. Two patients had vomiting with both bath temperatures. The main complaint referred by the patients as regards to the post-dialysis syndrome was fatigue, followed by lightheadedness. One patient complaint of post-dialysis headache with bath temperature at 37 ºC, and another one of cramps with bath temperature at 35.5 ºC.

With bath temperature at 37 ºC, the medians for HDSI, SIpostHD and RTpostHD were 0.3, 1, and 4, respectively. The patients' evolution as for baseline parameters of clinical intolerance or hypotension events is shown in table II. The improvement in patients' perception of symptoms and in the number of hypotension events after decreasing the dialysis bath temperature was relevant in those patients presenting worse tolerance to hemodialysis with the usual bath temperature of 37 ºC or that had more than one hypotension event per week. Patients whose baseline values of HDSI, SIpostHD or RTpostHd were equal or lower than the median, or those patients having no hypotension episodes or just one episode per week did not show any benefit from decreasing the dialysis bath temperature, or even their symptoms perception during the session got worse.

Median pre-dialysis baseline axillary temperature was 36.1 ºC. Nor baseline tolerance values, nor the number of hypotension events or their evolution were changed by decreasing the bath temperature whether baseline axillary temperature was above or below the median (data not shown).

Nor the presence of diabetes mellitus or arterial hypertension, nor bath conductivity used (14 mS/cm, 14,5 mS/cm or perfl) had an influence on symptomatology perception indexes or on the number of hypotension episodes, with any of both bath temperatures (data not shown).

At the end of the second study week, patients were asked what dialysis bath temperature did they prefer to continue their dialysis: the previous 37º C temperature they had been using (usual temperature), or the new 35.5 ºC temperature (low temperature). Nineteen patients (61%) patients showed a preference of the 35.5 ºC temperature, seven (23%) preferred the usual temperature, and for the remaining 5 (16%) it made no difference. Baseline axillary temperature was similar between patient groups (36 ± 0.4, 36.1 ± 0.4, 36.1 ± 0.4° C, respectively). Patients showing a preference for low bath temperature had poorer baseline parameters (table III).

As it was expected, patients showing a preference for low dialysis bath temperature were those experiencing a greater improvement when decreasing the bath temperature to 35.5 ºC: HE 1.5 ± 1.9 *vs.* 0.9 ± 1.4 episodes/week, $p < 0.05$; HDSI 1 ± 1 *vs.* 0.3 ± 0.4, $p < 0.01$; SIpostHD 1.6 ± 1 *vs.* 1.1 ± 0.9, $p < 0.05$; RTpostHD 7.1 ± 7.3 vs. 3.5 ± 3.5 hours, $p < 0.05$. In the twelve patients that preferred a dialysis bath temperature of 37 ºC or did not show any preference for one or the other, we did not observe any change in the above-mentioned parameters when decreasing the dialysis bath temperature (data not shown).

Table II. Evolution of patients after decreasing the bath temperature by degree of baseline tolerance to hemodialysis

Patients whose basal hemodialysis tolerance parameters were equal or lower than the median (HDSI ≤ 3, n = 14; SIpostHD ≤ 1, n = 15; TRpostHD ≤ 4 h, n = 15), or that presented one or none episode of hypotension per week (n = 11).

	Bath temperature		
	37 °C	35.5 °C	
HDSI	1.5 ± 0.9	0.3 ± 0.4	p < 0.001
SIpostHD	2.3 ± 0.6	1.5 ± 0.8	p < 0.01
RTpostHD	9.9 ± 6.3	1.4 ± 0.9	p < 0.001
HE	3.2 ± 1.4	1.8 ± 1.5	p < 0.01

Patients whose basal hemodialysis tolerance parameters were equal or lower than the median (HDSI ≤ 0,3, n = 17; SIpostHD ≤ 1, n = 16; TRpostHD ≤ 4 h, n = 16), or that presented one or none episode of hypotension per week (n = 20).

	Temperatura del baño		
	37 °C	35.5 °C	
HDSI	0 ± 0.1	0.3 ± 0.6	p < 0.05
SIpostHD	0.4 ± 0.4	0.5 ± 0.2	
RTpostHD	1.2 ± 1.6	0.6 ± 0.8	
HE	0.2 ± 0.4	0.4 ± 0.8	

HDSI: Symptomatology index during hemodialysis; SIpostHD: Symptomatology index post-hemodialysis; RTpostHD: recovery time from postdialysis symptomatology (hours); HE: hypotensive events during dialysis (events/week).

Table III. Dialysis tolerance with bath temperature at 37° C by temperature preference expressed by the patients

	Prefered bath temperature		
	35.5 °C (n = 19)	37 °C or indifferent (n = 12)	
HDSI	1 ± 1	0.2 ± 0.4	p < 0.01
SIpostHD	1.6 ± 1	0.9 ± 1.2	p = 0.07
RTpostHD	7.1 ± 7.3	2.8 ± 2.9	p < 0.05
HE	1.5 ± 1.9	0.6 ± 1	p = ns

HDSI: Symptomatology index during hemodialysis; SIpostHD: Symptomatology index post-hemodialysis; RTpostHD: recovery time from postdialysis symptomatology (hours); HE: hypotensive events during dialysis (events/week).

The 19 patients preferring a low dialysis bath temperature and the 5 indifferent patients continued dialysis with a bath temperature of 35.5 ºC, and in the remaining patients the temperature was returned to the previous one of 37 ºC. Two patients that initially did not show any preference for any of both temperatures further expressed their whish to return to the usual temperature of 37 ºC. The data from the sixth week, corresponding to the 22 patients that were kept with a low bath temperature were as follows: mean pre- and post-dialysis BP 132/74 and 128/70 mmHg, respectively, HE 0.4 ± 0.6 episodes/week, HDSI 0.3 ± 0.4, SIpostHD 0.9 ± 0.8. These results are similar to those obtained during the second study week.

DISCUSSION

In a non-selected hemodialysis population, the reduction of the bath temperature increases hemodynamic stability, decreases subjective evaluation of symptomatology during dialysis, and improves post-dialysis fatigue syndrome. These results are similar to those obtained more than 15 years ago with dialysis procedures very different from the ones we use nowadays[3-5].

By decreasing bath temperature from 37 to 35.5 ºC, patients end up the dialysis session with higher systolic blood pressure and lower heart rate, with the same ultrafiltration rate. Other authors have referred similar data[8, 12, 14, 15].

The decrease in bath temperature increases vascular reactivity[10] and achieves better preservation of cardiac output and central blood volume[14], facilitating the hemodynamic response to prevent hypotension episodes. In the general group, the incidence of hypotension episodes decreased although it did not reached statistical significance.

To know the evaluation the patient does of the level of discomfort experienced during the hemodialysis session we used the modified questionnaire by Cruz *et al.*[12] that allows for a quantification by means of a symptomatology index. Hemodialysis with low bath temperature is accompanied by a decrease of that index in the total group of patients. Other studies also analyzing the patient perception of dialysis quality have obtained similar results[12, 15].

Post-dialysis fatigue is a frequent complication that limits activity and quality of life of patients within the hours following hemodialysis session. It is a poorly studied syndrome in which the influence of bath temperature has never been studied among its possible causes[13]. In our study we have verify that the post-dialysis fatigue syndrome is related with bath temperature and that reduction of the latter decreases the perception of its severity and duration.

We may highlight that not all symptoms and all patients improve by decreasing the bath temperature. The incidence of cramps increases, a fact that we had already observed in a previous study with hemodialysis with acetate buffer[4]. As in other studies[5, 15], we have checked that the patients taking advantage of low dialysis bath temperature are those showing a poorer tolerance with a usual bath temperature. Patients with more than one hypotension episode per week and those with higher discomfort perception during hemodialysis or with a more severe post-dialysis syndrome were the ones improving with a bath temperature of 35.5 ºC. In the remaining patients, not only an improvement of analyzed parameters was not achieved but also subjective perception of symptoms during hemodialysis got worse. When patients were offered the possibility of choosing the bath temperature, the ones showing preference for a low temperature were precisely those referring symptoms with hemodialysis at the usual temperature, and therefore they were the ones obtaining a clinical benefit from bath temperature reduction.

Fine *et al.*[16] suggested the bath temperature should be reduced only in patients whose body temperature was lower, since they represent the group of patients improving with this measure. In our study axillary temperature was not related to clinical response and did not have an influence on the patients' preference for one bath temperature or the other. Other studies have not been able to correlate hemodynamic response to cold bath hemodialysis with body temperature[8]. Skin temperature does not help discriminating the group of patients that may benefit from reducing the bath temperature.

With the current available data we should admit that bath temperature is a hemodialysis issue that is not sufficiently explained. The rationale for using a bath temperature of 37 ºC is completely empirical[6] and comes from the figure that Wunderlich established as the normal body temperature in 1869, by means of a mercury thermometer he invented. This figure is being revised to set it lower in the general population[17]. On the other hand, it is a well known fact that the temperature in dialysis patients is lower than that of the healthy population[18]. According to these data, the mean predialysis axillary temperature during the first two weeks of our study was 36 and 36.1 ºC, respectively. These figures are lower than the mean values of 36.3 ºC reported in the literature for a healthy population[17].

The appearance of new monitors that measure the temperature of the blood within the arterial and venous lines has allowed looking deeply into the knowledge of hemodialysis-induced thermoregulation impairments. During the hemodialysis session a increase of heat production occurs and at the same time a negative energy balance takes place.[7] In order to achieve a neutral energy balance (thermoneutral dialysis) the body core temperature has to be raised with bath temperatures of about 37.5 ºC; in order to keep the body core temperature steady (isothermal dialysis) it is required to increase energy loss by means of a bath temperature of about 35.5 ºC or even lower, depending on the ultrafiltration rate[9, 10, 19].

The increase in body core temperature is an important cause of hemodynamic instability and thus isothermal dialysis is better tolerated than thermoneutral dialysis[10, 20]. Body temperature varies according to the site and measurement procedure. Body core temperature, that of the blood coming out the heart, is the one controlling the thermoregulatory mechanisms. Axillary temperature is lower than core temperature, tympanic temperature being closer to the latter[18]. In recent clinical research studies tympanic temperature is used as the reference method to measure core temperature in dialyzed patients[8, 12, 16, 19, 21, 22]. In a preliminary study in our patients, we have verified that tympanic temperature is 0.2-0.3 ºC higher than axillary temperature. In the present study we have used axillary temperature because it is the one usually determined at hemodialysis units. Moreover, although axillary temperature is lower than core temperature, the temperature of arterial blood reaching the dialyzer through an arteriovenous fistula is also lower[18].

We may conclude that in spite of the advances achieved, bath temperature still has a relevant influence in hemodialysis tolerance. Low temperature hemodialysis is specially indicated in patients with poor tolerance but is does not represent a measure to be generally applied. Not all patients benefit from it and we should not forget that it implies a negative energy balance which clinical repercussion still is to be determined. Individualization of bath temperature by means of thermal sensors[23] may be one of the clinical goals of hemodialysis within the years to come.

REFERENCES

1. Maggiore Q, Pizzarelli F, Zoccali C, Sisca S, Nicolo F, Parlongo S: Effect of extracorporeal blood cooling on dialytic arterial hypotension. *Proc Eur Dial Transplant Ass* 18: 597-602, 1981.
2. Sherman RA, Rubin MP, Cody RP, Eisinger RP: Amelioration of hemodialysis-associated hypotension by the use of cool dialysate. *Am J Kidney Dis* 5: 124-7, 1985.
3. Marcén R, Quereda C, Lamas S, Orofino L, Teruel JL, Ortuño J: Hypoxemia and dialysate temperature. *Nephron* 45: 74-5, 1987.
4. Marcén R, Quereda C, Orofino L, Lamas S, Teruel JL, Matesanz R, Ortuño J: Hemodialysis with low-temperature dialysate: A long-term experience. *Nephron* 49: 2932, 1988.
5. Orofino L, Marcén R, Quereda C, Villafruela JJ, Sabater J, Matesanz R, Pascual J, Ortuño J: Epidemiology of symptomatic hypotension in hemodialysis patients: is cool dialysate beneficial for all patients? *Am J Nephrol* 10; 177-80, 1990.
6. Bregman H, Daugirdas JT, Ing TS: Complicaciones de la hemodiálisis. En: *Manual de Diálisis*. Daugirdas JT, Blake PG, Ing TS (eds.). Masson S.A, Barcelona, pp. 155-77, 2003.
7. Kaufman AM, Morris AT, Lavarias VA, Wang Y, Leung JF, Glabman MB, Yusuf SA, Levoci AL, Polaschegg HD, Levin NW: Effects of controlled blood cooling on hemodynamic stability and urea kinetics during high-efficiency hemodialysis. *J Am Soc Nephrol* 9: 877-83, 1998.
8. Van der Sande FM, Kooman JP, Burema JHGA, Hameleers P, Kerkhofs AMM, Barendregt JM, Leunissen KML: Effect of dialysate temperature on energy balance during haemodialysis: Quantification of energy transfer from the extracorporeal circuit to the patient. *Am J Kidney Dis* 33: 1115-21, 1999.
9. Barendregt JNM, Kooman JP, Van der Sande FM, Buurma JHGA, Hameleers P, Kerkhofs AMM, Leunissen KML: The effect of dialysate temperature on energy transfer during hemodialysis. *Kidney Int* 55: 2598, 1999.
10. Van der Sande FM, Gladziwa U, Kooman JP, Böcker G, Leunissen KML: Energy transfer is the single most important factor for the difference in vascular response between isolated ultrafiltration and hemodialysis. *J Am Soc Nephrol* 11; 1512-7, 2000.
11. K/DOQI Clinical Practice Guidelines for Cardiovascular Disease in Dialysis Patients: intradialytic hypotension. *Am J Kidney Dis* 45 (Supl. 3): S76-S80, 2005.
12. Cruz DN, Mahnensmith RL, Brickel HM, Perazella MA: Midodrine and cool dialysate are effective therapies for symptomatic intradialytic hypotension. *Am J Kidney Dis* 33: 920-6, 1999.
13. Sklar A, Newman N, Scott R, Semenyuk L, Schultz J, Fiacco V: Identification of factors responsible for postdialysis fatigue. *Am J Kidney Dis* 34: 464-70, 1999.
14. Hoeben H, Abu-Alfa AK, Mahnensmith R, Perazella MA: Hemodynamics in patients with intradialytic hypotension treated with cool dialysate or midodrine. *Am J Kidney Dis* 39: 102-7, 2002.
15. Ayoub A, Finlayson M: Effect of cool temperature dialysate on the quality and patients' perception of hemodialysis. *Nephrol Dial Transplant* 19: 190-4, 2004.
16. Fine A, Penner B: The protective effect of cool dialysate is dependent on patients' predialysis temperature. *Am J Kidney Dis* 28: 262-5, 1996.
17. Sund-Levander M, Forsberg C, Wahren LK: Normal oral, rectal tympanic and axillary body temperature in adult men and women: a systematic literature review. *Scand J Caring Sci* 16: 122-8, 2002.
18. Pérgola PE, Habiba NM, Johnson JM: Body temperature regulation during hemodialysis in long-term patients: Is it time to change dialysate temperature prescription? *Am J Kidney Dis* 44: 155-65, 2004.
19. Rosales LM, Schneditz D, Morris AT, Rahmati S, Levin NW: Isothermic hemodialysis and ultrafiltration. *Am J Kidney Dis* 36: 353-61, 2000.
20. Maggiore Q, Pizzarelli F, Santoro A, Panzetta G, Bonforte G, Hannedouche T, Álvarez de Lara MªAª, Tsouras I, Lou-

reiro A, Ponce P, Sulková S, Van Roost G, Brink H, Kwan JTC: The effects of control of thermal balance on vascular stability in hemodialysis patients: results of the European Randomized Clinical Trial. *Am J Kidney Dis* 40: 280-90, 2002.
21. Schneditz D, Rosales L, Kaufman AM, Kaysen G, Levin NW: Heat accumulation with relative blood volume decrease. *Am J Kidney Dis* 40: 777-82, 2002.
22. Keijman JMG, Van der Sande FM, Kooman JP, Leunissen KML: Thermal energy balance and body temperature: comparison between isolated ultrafiltration and haemodialysis at different dialysate temperatures. *Nephrol Dial Transplant* 14: 2196-2200, 1999.
23. Passlick-Deetgen J, Bedenbender-Stoll E: Why thermosensing? A primer on thermoregulation. *Nephrol Dial Transplant* 20: 1784-9, 2005.