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Effect of Dialysate Temperature on Hemodynamic Stability among Hemodialysis Patients

Tarik A. Hussein[1] *FICMS*, **Arif S. Malik**[2] *FICMS*

[1]Al-Karkh Hospital for Emergency, Baghdad, Iraq, [2]Dept. of Medicine, College of Medicine, Al-Nahrain University

Abstract

Background Hypotension is one of the complications of hemodialysis treatment. It increases morbidity and mortality and can compromise the dialysis efficacy. Cooling the dialysate below 36.5°C is an important factor that contributes to hemodynamic stability in patients during hemodialysis.

Objective To assess the effect of dialysate temperature on hemodynamic stability during hemodialysis sessions, post dialysis fatigue and the adequacy of dialysis.

Methods A total of 40 patients were assessed during six dialysis sessions; in three sessions, the dialysate temperature was (37 °C) and in three other sessions, the dialysate temperature was (35 °C). Specific scale questionnaires were used in each dialysis session, to evaluate the symptoms during the dialysis procedure as well as post-dialysis fatigue, and respective scores were noted. Blood pressure, heart rate, temperature were recorded. Also dialysis efficacy using Kt/v, urea reduction ratio were measured.

Results The results showed that usage of low dialysate temperature was associated with the following : higher post dialysis systolic blood pressure ($P < 0.05$) and lower post dialysis heart rate ($P < 0.05$), better intra-dialysis symptoms score and post-dialysis fatigue scores ($P < 0.05$ and $P < 0.05$, respectively), shorter post-dialysis fatigue period ($P < 0.05$) as well as Similar urea removal and Kt/V .

Conclusion Cool dialysis is an important factor in hemodynamic stability during hemodialysis. Also it improves symptoms during and after hemodialysis. Cool dialysis has no effect on adequacy of dialysis.

Key words Hemodialysis, Cool dialysate, Hypotension, Hemodynamic

List of abbreviations: BP = blood pressure, Bu = blood urea, BUN = blood urea nitrogen, ESRD = end stage renal disease, HD = hemodialysis, URR = urea reduction ratio.

Introduction

Cooling of dialysate fluid below 36.5 °C has been proposed as a factor contributing to hemodynamic stability in patients during hemodialysis (HD) [(1)]. Cool dialysate improves cardiovascular tolerance in HD and reduces hypotension episodes without compromising the efficacy of HD [(2)]. Hypotension during HD is a source of considerable morbidity and mortality, as many as 20% to 50% of HD treatments are complicated by this problem [(3)]. Elderly patients and those with diabetes, as well as those with autonomic insufficiency and structural heart disease, are particularly affected [(4)].

The patients often suffer from variable combinations of nausea, vomiting, cramps, dizziness, and frank syncope, seizure like episodes, weakness, and fatigue both during and after dialysis sessions [(5)]. They may discontinue their sessions prematurely, resulting chronic underdialysis and fluid overload, also the patients may suffer from cerebrovascular insults and, myocardial ischemia [(5)].

During standard dialysis, the combination of low blood volume and loss of peripheral vascular resistance causes hypotension [6]. Loss of vascular resistance is multi factorial in cause, but uremic autonomic insufficiency, vasodilation from thermal amplification, and paradoxical withdrawal of sympathetic activity are believed to have the most important roles [6,7].

The improvement in blood pressure by using cool dialysate may be due to increased total peripheral resistance and increased venous tone. Cool temperature dialysate also improves left ventricular contractility independently of pre load and after load [8]. Post-dialysis fatigue is a frequent complication that limits activity and quality of life among patients in the period immediately following the HD session, cool dialysis is a presumed mechanism for improving this fatigue [8].

The aim of this study was to assess the impact of dialysate temperature on hemodynamic stability, efficacy of HD and on post-dialysis fatigue syndrome scoring assessment in patients on maintenance HD.

Methods

The cross sectional study is carried out on samples of patients in the dialysis unit of Al-Imamain Al-Kadhimain Medical City, Baghdad, for the period from April to May 2010, and compared the response at two dialysate temperatures: 37 °C as the usual temperature, and 35 °C as the low temperature. We used empiric fixed reduction of dialyaste temperature not isothermic dialysis.

Patients' selection

Forty patients were selected randomly, 23 males and 17 females, with ages ranging between 28 and 73 years. The mean and standard deviation were (48±13 years). The etiology of renal failure in study patients was shown in table 1. The vascular access used was an arteriovenous fistula in 35 patients, and a dual lumen catheter in subclavian vein in 5 patients. Twenty two were hypertensive and told to omit antihypertensive drugs at the day of HD and not to eat during the session. They continue on regular medications for end stage renal disease (ESRD).

The patients were assessed during six dialysis sessions; in three sessions, the dialysate temperature was normal (37 °C) and in three other sessions, the dialysate temperature was low (35 °C). Patients had dialysis two to three times per week, in 3-4 hour sessions.

Blood flow rate was in average of 200-250 mL/min, and dialysate flow rate equal to 500 mL/min. Dialyzer machine was GAMBRO Ak95S and all patients used hollow fiber dialyzers (GAMBRO) with synthetic membrane; polyflux 17 L, surface area = 1.7 m^2. The dialysate fluid consisted of the following constituents: sodium 140 mmol/L, potassium 2.0 mmol/L, calcium 1.5 mmol/L, magnesium 0.5 mmol/L, chloride 111.0 mmol/L, bicarbonate 32.0 mmol/L and acetate 3 mmol/L , osmolality 290 mmol/L.

The dialysis technique was conventional HD on all patients; no patient was on hemodiafiltration. Fluid removal was calculated as the difference between the patients' weight before and after a dialysis session. Blood pressure (BP) was determined with a mercury sphygmomanometer with the patient in sitting position, and axillary temperature was measured with a mercury thermometer. In patients having an arteriovenous fistula, the contralateral arm was used for BP measurements.

Body weight, blood pressure, pulse rate and axillary temperature were measured before dialysis. The BP, pulse rate, arterial line pressure, venous line pressure, blood flow rate were all checked half hourly during the session and the mean of these readings of each parameter for each patient was calculated and considered intradialytic reading. Weight, BP, pulse rate and temperature were recorded post-dialysis. Blood flow during dialysis was slowed to 100 mL/min before collecting post-dialysis blood samples for urea. The urea reduction ratio (URR) was calculated using the formula:

Urea pre - urea post/urea pre × 100 % [3].

Dialysis efficacy was measured by equilibrated Kt/V (Kt/ Veq). Kt/V is defined as the dialyzer as the dialyzer clearance of urea (K, obtained from the manufacturer in mL/min, and periodically measured and verified by the dialysis team) multiplied by the duration of the dialysis treatment (t, in minutes) divided by the volume of distribution of urea in the body (V, in mL), which is approximately equal to the total body water [9]. Kt/V values below 1.0 indicating under-dialysis and above 1.30 indicating adequate dialysis [9].

The single pool Kt/V (Kt/Vsp) was determined from the Daugirdas second generation formula [3].

$$Kt/Veq = (1- 0.47 / t) \times Kt/Vsp + 0.02$$

$$Kt/V\ sp = -\ln (R - 0.03) + [(4 - 3.5R) \times (UF \div W)]$$

UF is the ultrafiltration volume in liters, W is the postdialysis weight in kg, and R is the ratio of the postdialysis to predialysis BUN, t is treatment time in hours. We measured blood urea (BU) and converted to blood urea nitrogen (BUN) by this relation (BU = 2.141 BUN mg / dl) [10].

The number of hypotensive events, symptoms and complications were registered. A hypotensive event was defined according to the criteria established by Dialysis Outcomes Quality Initiative (DOQI) guidelines [11] which refer to:

1. Systolic BP below 100 mmHg, or
2. Decrease in systolic BP of 20 mmHg associated with symptoms such as nausea, vomiting, muscle cramps, dizziness or fainting, or
3. Decrease in systolic pressure more than 25 % [11].

Special questionnaire was administered during each session to assess hypotensive symptoms and to assess postdialysis fatigue syndrome, it contained 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 and scored 1 if it persisted for longer than half an hour it was considered moderate and scored 2, and if it persisted throughout the whole session, it was considered as severe and scored 3, if no discomfort noticed then scored 0 [12]. The grades were added to produce a total score. Patients were asked whether they felt cold at any time during or at the end of each HD treatment and considered one of the discomforts.

To assess postdialysis fatigue syndrome, before each dialysis session, the patient was asked the following questions:

How long did it take to recover from the last dialysis session?

What was the main complaint he/she had?

What level of discomfort did he/she experience?

The discomfort was considered mild if it did not prevent the patient from doing his/her usual activity and scored 1, moderate if his/her activity was limited but he/she did not have to take bed-rest and scored 2, severe if he/she had to take bed-rest to recover and scored 3; if no discomfort then it scored 0 [12]. Also grades were added to produce a total score. The periods of fatigue in hours were used as index.

Statistical analysis

Statistical analysis was performed using SPSS 14.0. The T test used to elicit the statistical significance concerning the comparison of multi characteristics or variables in two different set of temperatures. *P* values < 0.05 were considered as statistically significant

Results

The most common cause of renal failure in the study group was diabetic nephropathy, which constitutes about 45% of the patients (Table1).

Table 1. The main possible causes of renal failure

Etiology of renal failure	No.	%
Diabetic nephropathy	18	45
Hypertension	7	17.5
Clinical based glomerulonephritis	6	15
Pyelonephritis	6	15
Unknown cause	3	7.5

The changes noted in clinical parameters by decreasing the dialysate temperature are shown in table 2. Systolic BP decreased during and after dialysis in both dialysate 35°C and 37 °C. While this decrease was statistically significant in standard dialysis, it was not in cool dialysis. There is significant difference between cool and standard dialysis in postdialytic systolic pressure (*P* = 0.0104) but not in intradialytic systolic blood pressure (*P* = 0.1893). Diastolic blood pressure decreased in both dialyste temperatures not significantly, and there was not significant difference in diastolic blood pressure between the two conditions (*P* = 0.4395). There is a significant decrease in the number of hypotensive events when using cold dialysate (*P* = 0.0008).

Axillary temperature decreased after cool dialysis, and increased after standard dialysis with significant difference in postdialytic axillary temperature between the two dialyste temperatures (*P* < 0.05).

The heart rate increased with bath temperature at 37 °C and decreased with bath temperature at 35 °C with significant difference between the two baths in postdialysis, but not during the dialysis.

There is a significant difference in the scoring of symptomatology index during hemodialysis between the two baths (*P* < 0.001) with improvement by cool dialysate. In assessing postdialysis fatigue there was also improvement in symptomatology index with cool dialysis (*P* < 0.0134). Postdialysis fatigue period decreased in cool dialysis (*P* = 0.0064) as shown in table 2.

Table 2. Changes in clinical parameters in using two types of dialysate fluid

Clinical parameter	Dialysate Temperature		P value
	37ºC	35ºC	
Pre-dialysis temperature (ºC)	36.4 ± 0.3	36.3 ± 0.4	0.2097
Post-dialysis temperature (ºC)	36.8 ± 0.3	36.0 ± 0.3	< 0.001
Pre-dialysis systolic BP (mmHg)	145 ± 28	143 ± 29	0.7545
Intra-dialytic systolic BP(mmHg)	134 ± 26	142 ± 28	0.1893
Post-dialysis systolic BP (mmHg)	126±24	141 ± 27	0.0104
Pre-dialysis diastolic BP (mmHg)	91 ± 13	92 ± 11	0.7114
Intra-dialytic diastolic BP(mmHg)	90 ± 11	91 ± 10	0.6717
Post-dialysis diastolic blood pressure (mmHg)	88 ± 11	90 ± 12	0.4395
Pre-dialysis heart rate (beats/ minute)	83±10	82 ± 11	0.6717
Intra-dialytic heart rate (beats/ minute)	85 ± 12	81 ± 10	0.1034
Post-dialysis heart rate (beats/ minute)	85± 11	79 ± 9	0.0156
Hypotensive events	1.7± 0.9	1.1 ± 0.6	0.0008
Symptomatology index during hemodialysis	0.8 ± 0.2	0.5 ± 0.1	< 0.001
Post-hemodialysis fatigue symptomatology index	1.3 ± 0.4	1.1 ± 0.3	0.0134
Post-dialysis fatigue period (hours)	4.4 ± 1.3	3.7 ± 0.9	0.0064

The difference in Kt/Veq values with the use of cool dialysate (35 °C) and normal dialysate (37 °C) was statistically not significant. Also, there was non-significant difference in the URR between the two dialysate temperatures (Table 3).

Table 3. Changes in adequacy of dialysis by using two types dialysate fluids

Parameter	Dialysate temperature		P value
	37°C	35°C	
URR%	49.71 ± 2.21	50.21 ± 1.8	0.2706
Kt/Veq	0.901 ± 0.095	0.897±0.105	0.8587

Usage of cool dialysate resulted in maintaining hemodynamic stability with nearly similar ultrafiltration compared with normal dialysate (37 °C). Ultrfiltration at 37°C was 1.362 ± 0.273 L, and at 35°C was 1.397 ± 0.308 L. There was no significant difference between the two types of dialysis (P = 0.592).

Discussion

From the results of the study we found that reduction of the dialysate temperature from 37 °C to 35 °C, increases hemodynamic stability, decreased subjective symptomatology index during dialysis, and improves post dialysis fatigue syndrome. By decreasing dialysate temperature, patients complete the dialysis session with higher systolic blood pressure and lower heart rate, with nearly equal degree of ultrafiltration. Also reduction in dialysate temperature resulted in improvements in scoring system of post-hemodialysis fatigue symptomatology index. We choose 35 °C because several studies have shown that this degree of cooling produces the least variations in core body temperature (13,14).

The results of our study are in accordance with previous studies that showed improvement in haemodynamic stability when using cool dialysate (9,15,16) Compensatory physiological mechanism may play a role Removal of body heat by cool dialysis helped the patients to sustain their peripheral vasoconstriction and cardiac filling. Cool dialysate increases left ventricular contractility in hemodialysis patients (17). The stability of blood pressure during cool dialysis may at least in part be due to an increase in plasma norepinephrine concentrations, which is not observed during warm dialysis (18). Similarly, cooling of the blood during hemodialysis may result in physiologic responses such as skin vasoconstriction and shivering to restore body temperature which is considered pathophysiological sign carries bad outcomes (8).

Previous studies such as the study of Fine and Penner, suggested that dialysate temperature should be reduced only in patients whose body temperature was low, since they represent the group of patients who are likely to improve with this measure (9). Fine and Penner showed that dialysis patients with subnormal body temperature below 36°C dialyzed with 37 °C dialysate had the highest hypotesive episodes. Those patients who should most benefited from cool dialysate using 35 °C (9). In this study we did not find such relation. Skin temperature does not help in identifying which patients who benefit from cool dialysate. In our data nearly 95 % of the patients had predialysis temperature above 36°C, and improved with cool dialysis.

There were not significant differences in the Kt/V eq values between dialysis with cool dialysate and standard dialysate. Therefore, cool dialysate had no effect on urea removal and equilibrated Kt/V. In one study done by Azar in Egypt in 2009, he showed that cool dialysate increase the efficacy of dialysis (8).

Since cool dialysis causes increase in peripheral vascular resistance, some investigaters have expressed a concern that this haemodynamic effect could cause urea compartmentalization in vasocostricted bed and thus decrease in the efficiency of dialysis [3]. However, in this study efficacy of dialysis was not changed significantly by decreasing dialyste temperature. This may be due to the fact that vasoconstriction in cool dialysis involves mainly skin which contains only 10 % to 15 % of total body water and hence urea; so it has little impact on urea extraction [19].

From the results of this study it was that HD in dialysis unit is not adequate (Kt/V < 1). This may be attributed to many factors such as malnutrition, anemia, premature ending of dialysis session due to hypotension or other technical reasons, also non compliance of the patients, dialysate flow rate that is inappropriately low, dialyzer leaks. Inadequate blood flow from the vascular access, and blood clotting during dialysis, which reduces effective dialyzer surface area. This is may be the cause of non significant difference between cool and normal dialysate temperature regarding the adequacy of dialysis. In conclusion cool dialysis is an important factor in haemodynamic stability during HD. Also it improves scoring of symptoms during and after HD. Cool dialysis has no effect on adequacy of dialysis.

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Author contribution

Dr. Arif has designed the study and co-writes the manuscript, Dr. Tarik has collected and analyzed the data and write the manuscript.

Declaration of interest

The Authors declare no conflict of interest.

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Correspondance to Dr. Arif S, Malik
E-mail: dr_arif31@yahoo.com
Mobile: +964 7902868042
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