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VARIA

The effect of lowering the dialysate temperature on the stabilization of hemodynamic indices of diabetic patients admitted to Ali ibn Abi Talib Hospital, Zahedan: A clinical trial

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Abstract: *Introduction: One of the basic pillars of hemodialysis is its adequacy, which is achieved by stabilizing hemodynamic parameters. This is especially important in the hemodialysis adequacy of diabetic patients. The current study aims to determine the effect of lowering the dialysate temperature on hemodynamic indices and dialysis adequacy of diabetic patients.*

Materials and methods: This is a clinical trial that was performed on 32 diabetic patients admitted to the Dialysis Ward of Ali ibn Abi Talib Hospital affiliated with Zahedan University of Medical Sciences in 2017. The research subjects were selected using the convenience sampling method from eligible patients. Each patient underwent hemodialysis twice; i.e. routine dialysate temperature (37° C) and cold dialysate temperature (36 °C). Except for lowering the dialysate temperature to (36 °C), all other conditions were the same during the study. Blood pressure (BP) and pulse rate of patients were monitored before and after dialysis and during the first, second, and third hours after dialysis; however, the body temperature and weight of patients were monitored before and after each dialysis session. Patients' blood samples were collected at each stage before and after dialysis to evaluate urea and calculate dialysis adequacy. Data analysis was carried out using descriptive statistics, paired t-test, and one-way repeated measures ANOVA in SPSS Ver. 21. P-value <0.05 was considered as the significant level.

Results: Systolic, diastolic, and mean arterial blood pressure among patients who underwent hemodialysis with normal dialysate temperature were significantly lower than those who underwent hemodialysis with cold dialysate temperature (p<0.05). There were no significant differences between cold and routine dialysis in terms of changes in body temperature before and after dialysis. The dialysis adequacy at 36 °C showed a significant increase as compared to 37° C.

Conclusion: The results of the present study showed that hemodialysis with cold solution (36 °C) stabilized hemodynamic variables and improved dialysis adequacy among diabetic patients, therefore, this treatment is recommended in hemodialysis wards.

Keywords: *cold dialysis solution, hemodynamic indices, dialysis adequacy, hemodialysis, diabetic patients, chronic renal failure*

INTRODUCTION

Type 2 diabetes is one of the most common non-communicable diseases in the world and one of the 10 leading causes of death in many countries [1].

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In terms of the severity of the disease, 35% of dialysis patients with chronic renal failure are diabetic [2].

Chronic kidney disease is the most common and important complication of diabetes, which is associated with a range of different pathological processes and leads to an irreversible decrease in renal function. Among these pathological processes, end-stage renal disease (ESRD) is one of the most important and common life-threatening diseases, which is associated with severe or complete renal insufficiency in the excretion of waste products, urine concentration, and regulation of electrolytes [4]. Studies show a growing increase in the prevalence and incidence of ESRD patients in Iran, reaching from 24,000 in 2008 to 58,000 at the end of 2016, of which about 29,200 (95%) are undergoing hemodialysis and 1624 are undergoing peritoneal dialysis [5, 6]. Considering the prevalence of diabetes and hypertension, it is predicted that the number of kidney patients, dialysis patients, and kidney transplants will be doubled and reach at least 90,000 by 2022 [6]. Aghighi et al. reported that the number of these patients increased by more than 130% in Iran during 1997-2006, which indicates the need to pay attention to this disease [7].

Considering the average 7%growth in the number of these patients in Iran, hemodialysis is expected to remain the most important method of dialysis in the treatment of these patients and increase the life expectancy of these patients, however, hemodialysis-related complications and problems also affect the health of these patients [7, 8].

Despite many technological and technical advances in hemodialysis and its improvement, there are still many pre- and post-dialysis problems. Intradialytic hypotension (IDH) is the most common serious complication of hemodialysis, occurring in 5%-40% of hemodialysis treatments. Hypotension widely increases the overall mortality of patients and not only limits fluid removal during dialysis, but can also cause severe adverse vascular effects on mesentery, cerebral infarction, and ischemia. This condition increases the need for nursing care and has negative effects on their quality of life, which is especially important among diabetic dialysis patients [2]. Diabetic patients are at higher risk for IDH, which is due to the autonomic dysfunction and cardiovascular problems in these patients.

One of the effective solutions proposed to prevent IDH, which has also been used, is to reduce the temperature of the dialysate [11-16]. Hemodialysis patients, who are usually hypothermic, gain extra heat during the treatment session. It seems that the increase in body temperature is due to increased sympathetic activity and decreased ability to dissipate heat due to severe contraction of peripheral arteries and dilation of central arteries, and ultimately reduced cardiac output [17, 18].

A slight decrease in dialysate temperature of about 1-2 °C helps reverse these changes by increasing central venous artery tonicity, venous return, and cardiac output [20]. Mojerloo et al. used cold and routine dialysate and found that generally, hypotension rate was 18% and 5% among the dialysis groups treated with routine temperature and cold dialysate, respectively, and hypotension rate was significantly lower in the dialysis group with cold dialysate [21].

Because hemodialysis patients experience many problems due to the specific physical and mental conditions arising from their disease, and dialysis quality is an important factor and effective in reducing these problems, and one of the important parameters to improve dialysis adequacy is to stabilize hemodynamic indicators [16], there is a need to adequate standard hemodialysis by reducing side effects to reduce referrals among patients (especially diabetic patients) for hemodialysis. Considering the importance of the foregoing and the results of several studies, the use of cold dialysate is a simple and inexpensive method that can reduce the frequency of hypertension, stabilize hemodynamic indices, improve the hemodialysis quality, and thus improve quality of life and general health of diabetic patients undergoing hemodialysis [22-24]. Since there has been no similar study in the province, this study aimed to determine the effect of lowering the dialysate temperature on hemodynamic indices and dialysis adequacy of patients with type 2 diabetes admitted to Ali Ibn Abitaleb Hospital of Zahedan University of Medical Sciences in 2017.

METHODS

This quasi-experimental one-group study was carried out on 32 eligible patients with type 2 diabetes who referred for hemodialysis using convenience sampling. Inclusion criteria included being on dialysis for at least 3 months, non-use of antihypertensive drugs, weight gain up to three kg between hemodialysis sessions, and no anemia, malignant disease, and thyroid disorders. Information record form was made available to patients who expressed their consent to participate in the study. This form consisted of two parts; the first part included individual and clinical characteristics and the second part included calculating and recording the dialysis adequacy of each patient in each hemodialysis session.

The sample size was estimated at 14 people using the following sample size formula and taking into account the numerical values of the variables related to the study by

Mousavi et al. (2014), 95% confidence interval, and power= 95%. To increase the reliability of the results, the sample size was increased to 30 people; finally, it was increased to 32 people considering the possible drop-out.

$$n = \frac{(Z_1 - \frac{\alpha}{2} + Z_1 - \beta)^2 \sigma^2}{\delta^2} + \frac{Z_1^2 - \frac{\alpha}{2}}{2}$$

x̄1=83.94 Z1- β=1.64 Z1- α/2 = 1.96 S2=19.26

The study was performed in two stages. All patients underwent hemodialysis with a dialysate temperature of 37°C (routine dialysate) before the intervention. They then underwent hemodialysis with a dialysate temperature of 36°C (cold solution) in the next session. In other words, all patients underwent hemodialysis once with a routine dialysis solution (37°C) and once with a cold dialysis solution (36 °C) during two consecutive sessions. A sequence of dialysis with cold or routine dialysate for each patient was performed using random allocation where blue and green balls were used. The patient was asked to pick up a ball from the box containing 16 blue balls and 16 green balls. Blue and green balls represented the cold and routine dialysate in the first session, respectively. In the next session, the dialysis method was shifted. Hemodialysis variables were the same in both cases except for the solution temperature. All patients underwent hemodialysis 3 times a week for 3-4 hours each time. The mean body temperature of patients before hemodialysis was determined in the range of 37 °C and R5 polysulfane dialyzers made by the same company with the same ultrafiltration coefficient (High-flux) and bicarbonate dialysate (bicarbonate powder 650 g 35 Meql/lit, Pharmed Medical Industries Company), which was fixed during the study, was used for all patients. The equipment used, including dialysis machines equipped with an ultrafiltration control system (Fresenius model 4008-B), scales (Seca), and pressure gauges were investigated and confirmed. The dialysate flow rate was constant (500 Ml min).

The dialysate removal rate was calculated and determined for each patient based on the difference between pre-dialysis weight and dry weight (after dialysis). Blood flow rate (300 ml/min) was determined and 16-gauge needles were used. All parameters were constant on the machine until the end of the dialysis session. To measure pre-dialysis BUN level, an arterial blood sample was taken immediately before hemodialysis and after the hemodialysis session. To prepare a blood sample after dialysis, first, the pump speed was reduced to 100 cc per minute and another sample was taken from the arterial route 15 seconds later. All samples taken in the hospital laboratory were examined and the results were received. After measuring the research samples, the dialysis adequacy was calculated by KT/V method using the DaugirdasII formula, which is an internationally acceptable formula. Systolic blood pressure (SBP) and diastolic blood pressure (DBP), and mean arterial blood pressure (ABP) was calculated and recorded before, during (first, second and third hours) and at the end of hemodialysis. The patient's body temperature and heart rate (HR) were also measured before and after hemodialysis. KT/V index ≥ 1.2 and < 1.2 show dialysis with good and low adequacy, respectively. KT/V index values greater and lower than 1.2 indicate more and lower adequacy of dialysis.

Finally, the obtained data were entered into SPSS ver. 21 and analyzed. Descriptive analysis was carried out using mean, frequency, standard deviation, and percentage. A dependent t-test was used to evaluate the effect of cold dialysis on dialysis adequacy. P-value< 0.05 was considered as the significant level.

RESULTS

Of the 32 patients included in the study, 1 patient was excluded from the study due to being on a trip. The majority of people were female (45.2%) and married (83.9%), and 61.5% had the underlying disease. Mean ± SD of patients' age, duration of diabetes, duration of treatment, and weight gain was 60.5 ± 9.21 years, 12.07 ± 7.27 years, 21.82 ± 27.74 days, and 1.64 ±0.68 kg, respectively.

The results of comparing dialysis adequacy with cold and routine dialysate temperature (Table 1) showed a statistically significant difference between the two methods (p<0.001) and dialysis adequacy was higher in cold dialysis.

Table 1: Results of dialysis adequacy in two cold dialyzes and dialysis with routine temperature among hemodialysis patients

Dialysis method or group	Mean and standard deviation	Test result
Cold dialysis	1.14±0.34	P=0.001
Routine dialysis	0.98±0.20	P=0.001

DISCUSSIONS

The results of the present study on the mean systolic blood pressure in hemodialysis with cold and routine dialysate temperatures, before dialysis, 1, 2, and 3 hours of dialysis, and after dialysis showed no statistically significant differences between the two groups in terms of systolic blood pressure in the above five measurement periods except after the intervention (P =0.003).

The lack of a clear drop in SBP after intervention in the cold dialysis group indicates the effectiveness of cold dialysate in preventing a drop in SBP during dialysis.

The results of the present study are consistent with the study by Mojerloo et al. (2015) [21]. In the study entitled "The effect of lowering the dialysate temperature on the stability of hemodynamic variables in patients prone to hemodynamic instability under hemodialysis", Mousavi et al. (2014) showed that reducing the dialysate temperature to (35 °C), as compared to the standard dialysate temperature (37° C), prevents a drop in systolic, diastolic, and mean arterial blood pressure 2 and 3 hours of hemodialysis [25].

In a similar study conducted by Azar et al. (2009) in Egypt, patients were evaluated during 6-dialysis periods and results showed no change in systolic blood pressure after hemodialysis with cold dialysate [9].

Ayoob et al. (2004) carried out a study on two groups of patients, including 5 patients with periods of IDHs and 5 patients with stable BP during hemodialysis. Each patient underwent hemodialysis for three periods with cold dialysate (35 °C) and then three periods with standard dialysate (36.5 °C). The results showed that the mean arterial blood pressure during and after dialysis with dialysate was significantly high in the hypotensive group and did not change in the group with a stable BP [22].

The findings of the present study showed that lowering the dialysate temperature to (36 °C) compared to routine dialysate temperature (37 °C) could prevent SBP at the end of hemodialysis, although SBP did not decrease significantly during 1, 2 and 3 hours of dialysis. The results showed that hemodialysis with routine dialysate temperature reduces BP in patients during dialysis until the end of it.

Findings of the present study showed that the use of cold dialysate for diabetic patients prone to hypotension significantly prevents hypotension during and at the end of dialysis, which is consistent with the results of the study by Ayoob et al. (2004) [22].

The results of the present study are consistent with the results of similar studies conducted in Iran [17, 27]. Therefore, it can be concluded that IDH is more stable in hemodialysis with cold dialysate, and reduces the frequency of IDH. Also, the results showed no drop in DBP at different hours of dialysis in the cold dialysis group, however, there is an evident drop in DBP in the routine group, as we approach the last hours of dialysis, although the statistical tests did not show a significant difference in this regard. The results of the present study are consistent with the study by Mousavi et al. (2014). The results of their study showed a statistically significant difference between cold dialysate and routine dialysate in terms of DBP level suggesting that cold dialysate prevents pressure drop in DBP [25]. Therefore, it can be concluded that the cold dialysate can prevent a reduction in DBP.

The present study also investigated the mean ABP in routine and cold dialysate temperatures, before dialysis, during 1, 2, 3 hours of dialysis, and after dialysis. The results showed a significant difference between the two methods in terms of mean ABP. Although no statistically significant difference was observed between the two methods during hemodialysis in terms of mean ABP, it was relatively higher in the cold dialysate than routine dialysate ($p<0.001$), however, mean ABP was higher in the cold dialysate group than routine dialysate group.

The results of the present study are consistent with the study by Mousavi et al. (2014). They also found that routine dialysate led to a reduction in mean ABP [25]. Ayoob et al. also showed that the use of cold dialysate stabilizes blood pressure [22]. Considering the foregoing, it can be concluded that the use of cold dialysate stabilizes systolic and diastolic blood pressure and mean arterial pressure during and after hemodialysis. Cold dialysate causes hemodynamic stability during dialysis through various mechanisms, which include keeping the body temperature constant, increasing the activity of the sympathetic nervous system, and thus increasing the cardiac muscle contractile strength, and peripheral vascular resistance, stimulation of alpha-1 receptor in visceral arteries, followed by increased central circulatory volume and increased cardiac output [28-30]. Other studies also concluded that lowering the dialysate temperature reduced nitric oxide synthesis and thus reduced the frequency of hypotension [28].

The present study also investigated the mean HR in routine and cold dialysis methods, before dialysis, during 1, 2, 3 hours of dialysis, and after dialysis. Results showed no difference between the two methods in terms of HR changes, which are completely consistent with the study by Mousavi et al. (2014) [25], but inconsistent with the results of the study by Azar et al. (2009) [9] who found a significant difference in this variable. One of the reasons for the difference in the results may be attributed to the fact that bicarbonate-containing solutions are currently used, all of which contribute to the stability of patients' hemodynamic conditions and heart rate.

The present study also investigated the body temperature of patients who underwent hemodialysis with routine and cold dialysate before and after dialysis. Results showed that the body temperature was not significantly different before and after dialysis, but there was a significant difference in the mean changes of body temperature after hemodialysis. That is, the mean body temperature of people undergoing hemodialysis with routine dialysate was higher than that of

people undergoing hemodialysis with cold dialysate (P = 0.02).

The findings of the above study are consistent with the study by Borzoo et al. (2015). They found changes in clinical parameters with changes in dialysate temperature and the mean body temperature of patients decreased with decreasing dialysate temperature, meaning that the mean body temperature of patients who underwent hemodialysis with normal dialysate temperature (37 °C) was 0.12 and 0.27 higher than those underwent hemodialysis with at dialysate temperatures 36 °C and 35 °C, respectively [24]. Another important finding of the present study is the mean body temperature of patients in the two groups before dialysis, which is 36.9°C in the cold dialysis group and 36.8°C in the routine dialysis group, but the statistical tests did not show significant differences (p=0.11). These findings are not consistent with the results of previous studies, which indicate that the body temperature of dialysis patients is lower than the body temperature of normal people [24]. Anemia often leads to a decrease in internal body temperature, which leads to chills, especially in the extremities such as legs, arms, ears, and nose, even when the person is in a warm room. Therefore, using a solution with a temperature higher than body temperature can not only lead to the destabilization of cardiovascular conditions [9, 18, 24] but also causes discomfort in patients [31].

Considering the results of the current study suggesting the positive effect of cold dialysate on the dialysis adequacy and comfort of patients, it seems that the time has come for all patients not to be permanently dialyzed with a single dialysate temperature and the dialysate temperature to be determined according to patients' clinical conditions. The use of cold dialysate, which is both inexpensive and readily available, can prevent hemodynamic instability during hemodialysis and reduce the periodic occurrence of IDH. However, it should be noted that all patients may not benefit from this method, therefore, people who have a lower pre-dialysis temperature can benefit more from this method.

CONCLUSIONS

Considering the positive effects of cold dialysis on the hemodialysis adequacy and stabilization of hemodynamic variables, it is suggested that if there is no prohibition in this treatment, cold dialysate replaces the standard dialysate. It is recommended to carry out further studies on the effect of cold hemodialysis on hemodialysis adequacy in other groups, including non-diabetic patients.

Ethical considerations

The present study was registered in the Ethics Committee of Zahedan University of Medical Sciences with the number (IRZaums.REC.1396.292) and in the Iranian Registry of Clinical Trials with the code IRCT20171009036675N2.

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