Cold Dialysis Solution for Hemodialysis Patients With Fatigue
A Cross-over Study

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Introduction. The purpose of this study was to explore the effect of cold dialysis on fatigue in hemodialysis patients.
Materials and Methods. In a double-blinded cross-over clinical trial, 46 participants were recruited from a hemodialysis unit in Iran. The participants were allocated into 2 groups through simple random sampling method. Each group received 3 sessions of hemodialysis with a dialysis solution temperature of either 37°C 3 or 35.5°C during the first week and then with for another week with the other temperature. The self-report Piper Fatigue Scale questionnaire was filled out by the participants.
Results. The Piper Fatigue Scale scores in the cold dialysis groups were significantly lower than those in the conventional dialysis solution temperature ($P < .001$). Reducing the temperature of hemodialysis solution brought a 31.3% reduction in the fatigue score.
Conclusions. Cold dialysis can be used for all hemodialysis patients as a routine intervention, and in particular, it is recommended dialysis patients who have severe fatigue as a convenient and inexpensive therapeutic option.

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INTRODUCTION

Hemodialysis is still the most common therapeutic method for end-stage renal disease (ESRD).[1] The number of patients receiving hemodialysis has an annual increase of 15%.[2] According to the latest statistics, there were 16600 hemodialysis patients in Iran in 2007.[3] Although hemodialysis compensates the malfunctioning of the kidneys to some extent, ESRD patients suffer from various symptoms including fatigue, nausea, vomiting, sleep disorder, and irritation.[4] Postdialysis fatigue (PDF) is the most common complaint reported by individuals receiving long-term hemodialysis, and its occurrence rate has been reported to be from 60% to 97%.[5] It can have a variety of effects on hemodialysis patients' lives such as reducing their physical performance, quality of life, and ability to do daily activities. An increase in fatigue can lead to a decrease in survival.[6] Since fatigue has been reported to be a discomforting symptom, nurses must find effective ways to help in its management.[7] The management of fatigue is an essential part in improving hemodialysis patients' quality of life.[3]

Lee and colleagues defined the concept of fatigue as a chain, at one end of which tiredness and lack of vitality and at the other end, energy and joviality are located.[2] The North American Nursing Diagnostic Association has defined fatigue as a sense of weakness and a decrease in the capacity for doing mental and physical activities.[7] Fatigued people do not have their previous energy and do fewer activities while trying a lot for doing the least of their daily activities.[8]

Unfortunately, the investigation and control of fatigue is often overlooked compared with all organic and invisible symptoms.[9] Due to the sly onset of fatigue, many patients adapt themselves to lower levels of energy while being unaware of

its damaging intensity.[10] It might be supposed that fatigue is a natural component of the disease process or of treating the chronic failure of the kidney. If a nurse does not ask a patient about it, the patient will not speak about it either, and hence, such a prevalent problem would go unnoticed.[9] Regarding hemodialysis patients, fatigue is a multidimensional concept and is affected by physiological, psychological, social, and hemodialysis-related factors.[3-5] The physiological reasons include anemia, malnutrition, and uremia, inefficiency of dialysis, hyperparathyroidism, concurrent chronic diseases, inflammation, and medicinal disorders. The psychological reasons include stress, anxiety, sleep disorder, medication dependence, and depression.[7] The sociodemographic factor incorporate age, sex, race, job, educations, marital status, and social support. Finally, the dialysis-related factors pertain to dialysis modality, dialysis times, dialysis efficiency, and PDF.[5] Postdialysis fatigue is a prevalent complaint after receiving dialysis which is affected by dialysis technique and can vary from benign to severe while lasting for a few hours after dialysis or even more. Patients who experience PDF usually require 5 hours of sleep for recuperating from PDF.[11] Nonetheless, most hemodialysis patients may get longer to go through fatigue stage and hence they assume it as a major problem. These effects are in contrast to their levels of physical activity.[12]

After examining PDF on 45 patients, Lindsey and coworkers concluded that there was a significant correlation between the duration of recovery from dialysis and fatigue; in other words, the patients who took longer to recover had a higher level of PDF. In addition, the relationship between the duration of recovery and PDF was stronger after dialysis, while it became weaker at intersession period. The factors influencing PDF pathophysiology include ultrafiltration, dissemination, osmoses imbalance, blood pressure changes, interactions of blood and dialysis, and increase in the pressure level of membrane width.[5]

Controlling fatigue incorporates medicinal as well as nonmedicinal interventions.[7, 11] Most patients suffer from fatigue in spite of using any balancing medication.[13] Despite the achievements in the realm of treatment, fatigue and limitations of solutions and food are at the forefront of tension-inducing factors for dialysis.[14] Some studies have stated that using cold dialysis solution at less than 36.5°C acts as an important factor in patients' hemodynamic stability during hemodialysis.[15- 17] Furthermore, many studies have indicated that cold dialysis solution improves cardiovascular tolerance and reduces the occurrence of hypotension during hemodialysis.[15,16] Cold dialysis solution leads to hemodynamic stability during dialysis through different mechanisms. These mechanisms include stabilizing body temperature, increasing the activity of sympathetic nervous system and consequently increasing the contraction power of the heart and the resistance of peripheral vessels, and finally stimulating the α1 receptors within visceral vessels and accordingly reducing the capacity of visceral veins, which leads to increasing the central blood flow and the output of the heart. Furthermore, cold dialysis solution prevents the stimulation of monocytes.[16,17]

In Iran, there is a lack of studies examining the effect cold dialysis on fatigue in hemodialysis patient. Therefore, this study aimed to compare the effect of hemodialysis in cold temperatures with normal temperatures on fatigue in patients undergoing hemodialysis.

MATERIALS AND METHODS

Study Design and Setting

This study was a double-blinded cross-over clinical trial, conducted in the hemodialysis unit of Vlieasr Hospital in Arak, Iran, from August 2014 to the end of October 2014.

Participants

The sample size was initially decided to be 42 ($\alpha = 0.05$, $\beta = 0.20$) and then was increased up to 10% to be 46 individuals due to the possibility of attrition. Patients were selected after filling out written consent informed and meeting the inclusion criteria. The criteria for inclusion were the following: age greater than 18 years old, being afflicted to some degrees of fatigue (mild, moderate, and severe), referring consistently and regularly 3 times a week for receiving hemodialysis, receiving hemodialysis for at least 6 months, having hemodynamic stability, being able to listen and speak, having an acceptable level of alertness for responding to questions, having no dependence on narcotics, and no chronic anemia (hemoglobin < 8 g/dL).

Accordingly, the participants were allocated into 2 groups through simple random sampling method and then received dialysis for 2 weeks through a cross-over method; each patient was compared with himself or herself regarding the variables related to fatigue score, both before and after dialysis within 2 temperatures (dialysis solutions of 37°C and 35.5°C). In the first group, each patient received 3 sessions of hemodialysis in the 1st week (every other day) with a 37°C solution while he or she received 3 sessions of hemodialysis (every other day) in the 2nd week with a solution temperature of 35.5°C (group 1). The second group (group 2) received hemodialysis in the reversed manner of the first group. Dialysis was carried out 3 times per week, each time for 4 hours with the filter ps13-ps130-pes130-ps160-f6-f7-f8, the arterial blood flow of 280 min/mL to 350 min/mL, the dialysis solution speed of 500 min/mL, and the dialysis solution containing sodium, 106 mEq/L; calcium, 2.5 mEq/L; magnesium, 1 mEq/L; chloride, 111.5 mEq/L; acetate, 3.5 mEq/L; and bicarbonate, 32 mEq/L.

Measures

A self-reported questionnaire was used to collect data. This questionnaire consisted of 3 parts: demographic characteristics, disease-related data, and the Piper Fatigue Scale (PFS). Meanwhile, the demographic data checklist included sex, age, and marital status and the disease-related data pertained to the cause of the disease, the duration of the disease, the start time of the first hemodialysis, previous record of transplant and dialysis, all other accompanying diseases, and previous record of the disease in the family.

The PFS was released to the public in 1990 by Piper for carrying out clinical trials, and it was validated and used by different researchers, including Ismail-Pour Zanjany and colleagues in Iran.[18-20] This questionnaire contains 27 questions, items 2 to 23 of which are scored from zero to 10 on an 11-point scale. The PFS encompasses behavioral areas (items 2 to 8), emotional concepts (items 9 to 13), sensory (items 14 to 18), and temperamental or cognitive (items 19 to 22). Moreover, 5 items are included in the form of qualitative data in order to enrich the questionnaire which is not considered in the final scoring.[18]

Data Collection

The PFS questionnaire was filled out once for each patient to enter the study and also after each 3 sessions of dialysis (at the beginning of the 4th and 7th sessions). The researcher read and completed it for illiterate patients. Scoring is as follows: zero, lack of fatigue; 1 to 3, weak fatigue; 3 to 6, average fatigue; and 6 to 10, severe fatigue. The mean of the total score on this scale is between zero to 10 and a higher score represents a higher level of fatigue.[18] The weighing scale for patients, dialysis machines, and barometer were calibrated by a technician and their precision was assured. Blood pressure and heartbeat were controlled and recorded by a digital arm-fit stethoscope from the arm through arterial-vascular fistula before, during, and after dialysis, while the patients were at sitting position. The armpit temperature was controlled and recorded by a mercury-filled thermometer before and after dialysis. The room temperature was controlled at 23°C to 24°C in low-air condition.

Statistical Analysis

Data were analyzed using the SPSS software (Statistical Package for the Social Sciences, version 20.0, SPSS Inc, Chicago, IL, USA). Descriptive statistics of continuous variables were shown as mean ± standard deviation. The Student *t* test, the paired *t* test, and the Fisher exact test were used for comparisons. A *P* value less than .05 was considered significant.

RESULTS

Forty-six patients experiencing PDF, with a mean age of 58.46 ± 13.46 years, participated in the study. Characteristics of the participants are shown in Table 1. The duration of receiving dialysis was between 6 and 174 months (mean, 42.60 ± 46.78 months). Vascular access was through the auto-log arterial-vascular fistula in 41 individuals (89.1%), central vein catheter in 4 (8.7%), and arterial-vein graft in 1 (2.2%). The reasons leading to ESRD were diabetes mellitus for 22 individuals (47.8%), hypertension for 9 (19.6%), polycystic kidney for 4 (8.7%), glomerulonephritis for 1 (2.2%), unknown causes for 5 (10.9%), and all other reasons for 5 individuals (10.6%). In total, 43.5% of the patients had average fatigue while 56.5% had severe fatigue.

The findings related to the comparison of patients' mean score of fatigue in both groups are presented

Table 1. Demographic Characteristics of Participants*

Category	Group 1	Group 2
Sex		
Female	7 (15.3)	14 (30.4)
Male	16 (34.8)	9 (19.5)
Marital status		
Single	1 (2.1)	2 (4.4)
Married	22 (47.8)	20 (43.5)
Widowed	0	1 (2.2)
Education		
None	8 (17.4)	16 (34.8)
School	3 (6.5)	2 (4.4)
High school	10 (21.7)	5 (10.8)
College	2 (4.4)	0

*Group 1 received conventional dialysis solution during the 1st week and then cold dialysis solution in the 2nd week, while group 2 received dialysis with a reverse order.

in Table 2. The findings indicated that the difference of fatigue score was not significant before and after dialysis at 37°C, while this difference was significant for the dialysis at 35.5°C in the behavioral, emotional, sensational and cognitive dimensions ($P < .001$). The total score of fatigue before the admission of patients into the study in both groups was more than 6 and also more than 6 after dialysis with a solution of 37°C. Meanwhile, it was 3.1 for group 1 and 2.9 for group 2 when using cold dialysis which proved a significant difference for both groups ($P < .001$).

DISCUSSION

The results of the present study confirmed that reducing the temperature of hemodialysis solution to 35.5°C led to decreasing PDF syndrome. In a studies on hemodialysis patients who had stable clinical conditions, the patients received dialysis for 2 consecutive weeks at 37°C and 35°C.[15] In order to examine PDF syndrome, a Scholar modified questionnaire was employed. The results of this study was in line with another similar study indicating that cold dialysis leads to a reduction in the intensity and length of PDF and also causes patients to feel more energetic after dialysis.[15,16] In another study, the length of PDF reduced from 9.9 hours to 1.4 hours.[17] Moreover, patients' symptoms in both studies had a significant difference after receiving cold dialysis.[16,17] In our research, after reducing the temperature of the dialysis solution, PDF score in group 1 decreased from 6.07 to 3.1, while it decreased from 6.2 to 2.9 in group 2. Furthermore, patients mostly felt fatigued after some hours from receiving dialysis while they had a few hours of being fatigued before dialysis and some days after dialysis.

Decreasing the temperature of the dialysis solution increases the tenacity and resistance of peripheral vascular and results in an increase in

Table 2. Fatigue Scores Before and After Dialysis With Warm (37°C) and Cold (35.5°C) Dialysis Solutions*

Fatigue Scale Dimension	Group 1			Group 2		
	Warm Dialysis	Cold Dialysis	*P*	Cold Dialysis	Warm Dialysis	*P*
Behavioral						
Before dialysis	6.7 ± 2.1	6.7 ± 2.1	.66	7.1 ± 2.5	7.0 ± 2.1	.66
After dialysis	6.8 ± 1.8	3.6 ± 1.4	.52	3.5 ± 1.5	7.1 ± 1.9	.71
Before-after *P*	.62	< .001		< .001	.21	
Emotional						
Before dialysis	6.5 ± 1.9	6.5 ± 1.9	.88	6.6 ± 2.3	6.6 ± 2.0	.88
After dialysis	6.5 ± 1.8	3.6 ± 1.3	.61	3.2 ± 1.2	6.8 ± 2.1	.37
Before-after *P*	.83	< .001		< .001	.22	
Cognitive						
Before dialysis	4.5 ± 1.9	4.5 ± 1.9	.63	4.7 ± 1.7	4.7 ± 1.7	.63
After dialysis	4.4 ± 1.9	2.1 ± 1.4	.54	2.2 ± 1.2	4.9 ± 1.7	.91
Before-after *P*	.22	< .001		< .001	.42	
Sensory						
Before dialysis	6.2 ± 1.8	6.2 ± 1.8	.97	6.2 ± 1.7	6.2 ± 1.7	.97
After dialysis	6.2 ± 1.9	2.7 ± 1.3	.88	2.4 ± 1.2	6.3 ± 1.8	.41
Before-after *P*	.85	< .001		< .001	.72	
Total						
Before dialysis	6.1 ± 1.6	6.1 ± 1.60	.74	6.2 ± 1.7	6.2 ± 1.7	.74
After dialysis	6.1 ± 1.6	3.1 ± 1.27	.54	2.9 ± 1.3	6.4 ± 1.7	.61
Before-after *P*	.72	< .001		< .001	.26	

*Group 1 received conventional dialysis solution during the 1st week and then cold dialysis solution in the 2nd week, while group 2 received dialysis with a reverse order.

blood pressure through this mechanism.[15] In the present study, the systolic and diastolic blood pressure increased after using cold dialysis. The mean of heart beat after dialysis at 37°C was more than the predialysis rate, while the mean of heart beat was decreased after using cold dialysis; however, these differences were not significant. On the other hand, in 2 studies, the systolic blood pressure increased after using cold dialysis while heartbeat decreased and the diastolic blood pressure did not have any change.[16,23] No bradycardia was observed after using cold dialysis in several other studies. All studies referred to cold dialysis disorder as cramp, shiver, and sense of coldness.[15-17] Still, the patients in our study did not suffer from cramp after receiving cold dialysis, but 16 individuals (34.8%) felt cold which did not require any special measure to be taken.

The reason behind using the 37°C solution was completely experimental and according to body temperature which has been reconsidered for researching on general population. On the one hand, it has been recognized that body temperature in dialysis patients is less than healthy people.[24] Still, according to the obtained data, the average armpit temperature is 36.24°C before dialysis which is less than the average value of 36.3°C, which has been mentioned in the literature about healthy people.[15] In Teruel and colleagues and Azar's studies, cold dialysis brought about a decrease in temperature after dialysis.[15,16] However, reduction of temperature was observed for one group while using cold dialysis.

Among the demographic factors in our research including age, sex, education, marital status, job, the etiology leading to dialysis, the type of vascular access, and blood group, a correlation was observed between education and fatigue score, in a way that fatigue score was higher among illiterate patients. In contrast to our study, in some studies, it was found that there is a correlation between fatigue and increase in age,[25,26] sex,[25,27,28] and employment status,[25,26] and thus, there was higher level of fatigue among older ages, women, and the unemployed. In order to examine this correlation, there is a need to a bigger sample size while ample number of patients had not been planned for. In their studies, Liu and Boner and colleagues indicated that as level of education goes higher; fatigue decreased which might have been due to this fact that highly educated individuals have more strategies at their disposal for counteracting fatigue.[29,30]

In the present study, we could reduce fatigue score up to 31.3% through properly adjusting one of the parameters in dialysis machine while this intervention in a research decreased PDF score up to 19.2% during 4 weeks of being trained.[31] In the present study, most of the researched individuals were male, retired or unemployed. Studies show that the rate of joblessness is high among hemodialysis patients who might be due to fatigue and lack of energy for carrying out activities. This factor incurs a lot of costs on patient, his/her family and society as a result of losing job.[26,29] Cold dialysis, like all other interventions, can be used for the hemodialysis patients and its application is recommended for dialysis patients who have severe fatigue as a convenient and inexpensive therapy.

CONCLUSIONS

The present study confirms the high prevalence rate of fatigue among dialysis patients. Reducing the temperature of hemodialysis solution from 37°C to 35.5°C brought about a 31.3% of reduction in PDF score. Cold dialysis can be used for each patient as any other intervention, which is recommended to be used for dialysis patients who have severe fatigue as a convenient and inexpensive treatment option. One of the limitations of the present study was the small sample size; hence, it is suggested that further studies be done with a larger sample size.

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CONFLICT OF INTEREST

None declared.

REFERENCES

1. Longo DL, Kasper DL, Jameson L, Fauci AS, Hauser SL, Loscalzo J. Harrison's principles of internal medicine. 18th ed. Philadelphia: McGraw-Hill; 2012.
2. Lee BO, Lin CC, Chaboyer W, Chiang CL, Hung CC. The fatigue experience of hemodialysis patients in Taiwan. J Clin Nurs. 2007;16:407-13.
3. Kazemi M, Nasrabadi AN, Hasanpour M, Hassankhani H, Mills J. Experience of Iranian persons receiving hemodialysis: a descriptive, exploratory study. Nurs Health Sci. 2011;13:88-93.
4. Horigan AE. Fatigue in Hemodialysis Patients: A Review of Current Knowledge. J Pain Symptom Manage. 2012;44:715-24.
5. Jhamb M, Weisbord SD, Steel JL, Unruh M. Fatigue in patients receiving maintenance dialysis: a review of definitions, measures, and contributing factors. Am J Kidney Dis. 2008;52:353-65.
6. Abdel-Kader K, Jhamb M, Mandich L A, et al. Ecological momentary assessment of fatigue, sleepiness, and exhaustion in ESKD. BMC Nephrol. 2014;6:15-29.
7. Bossola M, Vulpio C, Tazza L. Fatigue in chronic dialysis patients. Semin Dial. 2011; 24:550-5.
8. Jablonski A. The multidimensional characteristics of symptoms reported by patient on hemodialysis. Nephrol Nurs J. 2007;34:29-37.
9. O'Sullivan D, McCarthy G. Exploring the symptom of fatigue in patients with end stage renal disease. Nephrol Nurs J. 2009;36:37-9.
10. Straub CK, Murphy SO, Rosenblum R. Exercise in the management of fatigue in patients on peritoneal dialysis. Nephrol Nurs J. 2008;35:469-75.
11. Horigan AE, Schneider SM, Docherty S, Barroso J. The experience and self-management of fatigue in patients on hemodialysis. Nephrol Nurs J. 2013;40:113-22.
12. Sakkas G k, Karatzaferi C. Hemodialysis fatigue: just "simple" fatigue or a syndrome on its own right? Front. Physiol. 2012;31:302-6.
13. Putzki N, Katsarava Z, Vago S, Diener HC, Limmroth V. Prevalence and severity of multiple-sclerosis-associated fatigue in treated and untreated patients. Eur Neurol. 2008;59:42-136.
14. Logan SM, Pelletier-Hibbert M, Hodgins M. Stressors and coping of in-hospital haemodialysis patients aged 65 years and over. J Adv Nurs. 2006;56:91-382.
15. Azar AT. Effect of dialysate temperature on hemodynamic stability among hemodialysis patients. Saudi J Kidney Dis Transpl. 2009;20:596-603.
16. Teruel JL, Martins J, Merino JL, Fernandez Lucas M, Rivera M, Marcen R, et al. Temperature dialysate and hemodialysis tolerance. Nefrologia. 2006;26:461-8.
17. Moattari M, Azarhooshang P, Abbasian A, ReisJalali GH, Rajaeefard AR. [The effect of cool dialysate on intradialytic hypotension among end stage renal disease patients]. Res Med. 2007;31:67-72. Persian
18. Ostlund U, Gustavsson P, Furst CJ. Translation and cultural adaptation of the piper fatigue scale for use in Sweden. Eur J Oncol Nurs. 2007;11:133-40.
19. Mota DD, Pimenta CA, Piper BF. Fatigue in Brazilian cancer patients, caregivers and nursing students: a psychometric validation study of the Piper fatigue scale-revised. Support Care Cancer. 2009;17:645-52.
20. Giacalone A, Polesel J, De Paoli A, et al. Assessing cancer-related fatigue: the psychometric properties of the revised Piper fatigue scale in Italian cancer inpatients. Support Care Cancer. 2010;18:1191-7.
21. Annunziata MA, Muzzati B, Mella S, Narciso D, Giacalone A, Frantio L and et al. The revised Piper fatigue scale (PFS-R) for Italian cancer patients: a validation study. Tumori. 2010;96:276-81.
22. Ismail-pour Zanjany S, Farahani B, Dormanesh B, Zare M. [The effects of oral vitamin C on fatigue in hemodialysis patients in selected hospitals of the Army University of Medical sciences in 2009]. JAUMS. 2009;7:162-8. Persian
23. Tsay SL. Acupressure and fatigue in patients with end-stage renal disease–a randomized controlled trial. Int Nurs Stud. 2004;41:99-106.
24. Izadpanah A, Sahbaei F, Shojaei F, Fesharaki M. [Effect of Foot Reflexology on Fatigue in Women Admitted to Rama Spa Massage Service Center]. J Health Care. 2012;14:35-43. Persian
25. Kutner NG, Brogan D, Fielding B, Hall WD. Black/white differences in symptoms and health satisfaction reported by older hemodialysis patients. Ethn Dis. 2000;10:328-33.
26. Jhamb M, Pike F, Ramer S, et al. Impact of fatigue on outcomes in the hemodialysis (HEMO) study. Am J Nephrol. 2011;33:515-23.
27. Morsch CM, Goncalves LF, Barros E. Health-related quality of life among haemodialysis patients-relationship with clinical indicators, morbidity and mortality. J Clin Nurs. 2006; 15:498-504.
28. O'Sullivan D, McCarthy G. An exploration of the relationship between fatigue and physical functioning in patients with end stage renal disease receiving haemodialysis. J Clin Nurs 2007;16:276-84.
29. Liu HE. Fatigue and associated factors in hemodialysis patients in Taiwan. Res Nurs Health. 2006;29:40-50.
30. Bonner A, Wellard S, Caltabiano M. Levels of fatigue in people with ESRD living in far North Queensland. J Clin Nurs. 2008;17:90-8.
31. Fazel Asgarpoor A, Amini Z, Zeraati A, Esmaeli H. [The effect of a care plan based on the Roy Adaptation Model on level of Fatigue in hemodialysis patients]. J Evidence-Based Care. 2011:1:77-90. Persian

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