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The Effect of Dialysis Solution Temperature and Stepwise Ultrafiltration Profile on Dialysis Adequacy and Pruritus in Hemodialysis Patients: A Quasi-experimental Study

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Abstract

Background: Patients with renal insufficiency who receive hemodialysis should be continuously monitored to avoid possible complications, as they are at increased risk of several problems, including pruritus, as one of the most annoying problems. It seems that dialysis adequacy affects the pruritus of hemodialysis patients.
Objective: The current study aimed to investigate the effect of dialysis solution temperature and stepwise ultrafiltration profile on dialysis adequacy and pruritus of hemodialysis patients.
Methods: Following a single group quasi-experimental design, 34 eligible hemodialysis patients admitted to the hemodialysis ward of Zahedan Medical Center (Iran) in 2020 were recruited using the convenience sampling technique. All patients attended three standard dialysis sessions (at a temperature of 37°C) and three cold dialysis sessions (36°C) with a stepwise dialysis ultrafiltration profile. Dialysis adequacy was measured at the end of each session, and Yosipovitch's Pruritus Severity Scale (PSS) was filled before and after each dialysis session. Data were summarized using descriptive statistics (i.e., frequency, mean, and standard deviation). Mean scores before and after dialysis were paired by t-test using SPSS version 22. Statistical significance was considered when P-value < 0.05.
Results: The mean and standard deviation of dialysis adequacy in both standard dialysis and cold dialysis techniques with stepwise ultrafiltration profile were 1.18 ± 0.36 and 1.44 ± 0.48, respectively, indicating that dialysis adequacy of the cold dialysis method with stepwise ultrafiltration profile was significantly higher ($P = 0.001$). Besides, the mean pruritus scores in the standard dialysis and cold dialysis methods with stepwise ultrafiltration profile were -0.73 ± 0.80 and -1.73 ± 1.16, respectively, showing a significant difference ($P = 0.001$).
Conclusions: Cold hemodialysis with a stepwise ultrafiltration profile can be used as a simple and low-cost technique to improve both dialysis adequacy and relieve pruritus in hemodialysis patients.

Keywords: Hemodialysis Solution, Pruritus, Dialysis Adequacy, Ultrafiltration

1. Background

Chronic kidney disease (CKD) is associated with an increased risk of different pathological processes that lead to an irreversible decline in kidney function. In addition, it is a major and common life-threatening disease (1) that has turned into a major public health concern worldwide, including in Iran (2, 3). The global prevalence of CKD is 2 - 3%, and it doubles every 7 years. It is estimated that every year CKD claims 60,000 lives worldwide. In Iran, the incidence of CKD increases by 15% each year, 95% of whom undergo hemodialysis and 5% peritoneal dialysis (4). Patients with kidney failure suffer from several problems, one of the most important of which is pruritus (5), which causes minor irritation when it is localized and transient, but in severe and diffuses cases, it is intolerable and disabling, even may cause suicide (6). Several studies reported a high rate of pruritus among hemodialysis patients (5, 7, 8), both in Iran and other countries. Pruritus control facilitates tolerating hemodialysis (9). Nurses' efficiency in managing these complications is very important (10). Hence, nursing care plans (NCPs) of these patients are focused on the prevention of such complications, mainly thorough examina-

tion and planning (11). In other words, one of the important outcomes of NCPs for hemodialysis patients is to prevent adverse physiological complications creating a positive effect on patients' physical and mental health (12). Therefore, the longtime emphasis of NCPs on meeting patients' has led nurses to find new ways to relieve patients from these complications (13, 14). A major way to control the pruritus, as a complication in hemodialysis patients, is to apply cold dialysis solutions (15). Pruritus relief using cooling is a common scientifically approved experience. Accordingly, in the face of cold, the ion channels of temperature-sensitive receptors are disconnected from the terminals of pruritus-transmitting neurons, thus controlling pruritus (16). Besides, some studies (e.g. Lin et al., (2012)) showed that 26% of hemodialysis patients complained of heat sensation in areas with pruritus (17). Therefore, cold-based techniques such as cold dialysis solution can be used to relieve pruritus. For instance, Imani et al. (2018) showed that the use of cold dialysis solutions could relieve uremic pruritus in patients undergoing hemodialysis (15). In another study, Sarbaz et al. (2019) showed that the use of cold solutions improved the quality of dialysis (18). Moreover, it can be argued that dialysis adequacy can affect the pruritus of hemodialysis patients. Decreased kidney function or the inadequacy of kidney replacement therapies may result in increased accumulation of waste products in the body, which in turn may stimulate the skin pruritus process (19). Therefore, the severity of pruritus can be reduced by improving dialysis adequacy. Previous studies showed that the use of cold dialysis solutions not only is associated with improved dialysis adequacy but also may lead to the stabilization of patients' hemodynamic variables (18, 20). Dialysis adequacy can be considered an important and effective factor to reduce clinical problems like pruritus (21). Some studies reported that inadequate hemodialysis is associated with an increased risk of insufficient control of blood toxins and clinical complications, which in turn leads to multiple problems and disabilities, and even death (22). Numerous known factors can affect dialysis adequacy, including diet, type of filtration, machine speed, dialysis time, patient education, and underlying diseases, especially diabetes (23). Another effective factor is the use of the stepwise ultrafiltration profile. Some studies reported that the stepwise ultrafiltration profile could increase dialysis adequacy compared to the routine method (24). The stepwise ultrafiltration profiles are usually administered to extract a large portion of the total UF (ultrafiltration) volume in the first part of the hemodialysis session in which patients have the most fluid required for increasing the plasma oncotic pressure. It also provides a greater stimulus to fill the arteries (25). In stepwise ultrafiltration profiles, a gradual reduction or intermittent cessation of ultrafiltration is used to allow the intravascular volume to replenish. However, high dialysis fluid flow causes increased levels of urea diffusion and ultrafiltration (24). In addition to ultrafiltration, the use of cold hemodialysis solution seems to be highly useful for the management of complications both during and after dialysis, except for special cases (18). In other words, changing the temperature of the hemodialysis solution can improve both dialysis adequacy and stabilization of hemodynamic variables. It's also useful for the management of complications like pruritus and improving the comfort of hemodialysis patients. A majority of studies have addressed cold dialysis. However, a few studies have employed this method in conjunction with the stepwise ultrafiltration profile. One of the most important nursing challenges is to find the best strategy to increase dialysis adequacy, which is of crucial importance for the management of complications. Given the severity of these problems and limited studies conducted on this topic, further studies are needed to extend our knowledge. A review of the literature suggested that no study has explored these variables simultaneously.

2. Objectives

The current study aimed to evaluate the effect of cold dialysis with stepwise ultrafiltration profiles on pruritus and hemodialysis adequacy.

3. Methods

Following a single-group quasi-experimental design, the current study was conducted in 2020 after obtaining the approval of the Vice-Chancellor for Research and Technology and the Ethics Committee of Zahedan University of Medical Sciences (ZUMS) (Iran). The sample size was estimated as 34 subjects, based on the study by Imani et al. (15), with a 95% confidence interval and 90% statistical test power.

Hence, 34 hemodialysis patients admitted to medical centers of ZUMS were recruited. The inclusion criteria were undergoing hemodialysis for at least three months, a maximum weight gain of 3 kg between the sessions, obtaining a pruritus score of 17 or higher according to the pruritus severity scale, having no neurological or skin disease, no concomitant malignancy, undergoing hemodialysis three times a week, and having normal or high blood pressure. The exclusion criteria were patient death, intolerance to cold dialysis, unwillingness to participate or continue the study, transplantation, and systolic blood pressure declined by more than 30% of baseline blood pressure

during dialysis. Participants were selected using single-group convenience sampling.

Before starting the study, information regarding the objectives of the study were provided to the participants. Then, if agreeing, informed written consent was obtained from them. Data were collected using a demographic and clinical information form (i.e., age, gender, marital status, education, occupation, dialysis duration, underlying diseases, and drug use for pruritus), Yosipovitch's Pruritus Severity Scale (PSS), and a checklist for recording laboratory and adequacy values. PSS is a five-point Likert scale, in which the total score ranges from 1 to 48. This tool is designed to measure pruritus time, pruritus severity, pruritus location, pruritus frequency, and nighttime sleep. Those with a score of 1 to 16 are categorized as mild pruritus, 17 to 32 as moderate pruritus, and 33 to 48 as severe pruritus. Yosipovitch et al. (2001) evaluated the internal consistency of this instrument and reported a Cronbach's alpha of 0.75 (26). Abbasi et al. (2011) translated this instrument to Farsi. Besides, they reported a coefficient of 0.72 (P = 0.01) (27). In the present study, we found a Cronbach's alpha coefficient of 0.86. To evaluate the dialysis adequacy, urea and creatinine samples were taken from the arterial line immediately in each session before heparin injection. At the end of the dialysis session and before filtration, the blood flow rate was reduced to 100 mL/min for 10 seconds. After stopping the blood pump, second blood samples were taken to measure urea and creatinine.

After performing laboratory tests, dialysis adequacy was calculated using the Kt/V formula. The PSS was filled by the researcher both at the beginning and end of dialysis sessions. The patients underwent hemodialysis in the first three standard dialysis sessions, followed by three sessions of cold dialysis with a stepwise ultrafiltration profile. The dialysis solution temperature in the standard dialysis technique was 37°C. Besides, the temperature was 36°C in the cold dialysis with the stepwise ultrafiltration profile. The fluid was removed in a stepwise manner. To match the conditions in both standard and cold dialysis modes, hemodialysis variables, except for the solution temperature and the stepwise ultrafiltration profile, were the same. Data were analyzed using SPSS version 22. Data are described using descriptive statistics such as frequency, percentage, mean, and standard deviation. To compare mean scores before and after dialysis, a paired-samples t-test was applied. Furthermore, the Shapiro-Wilk test was applied to test for a normal distribution. Statistical significance was considered when P-value < 0.05.

4. Results

In the present study, data of 34 patients were analyzed. The mean age of participants was 48.11 years, and 58.8% were male, 58.3% were married, and 54% were illiterate. The mean and standard deviation (SD) of dialysis adequacy in both standard dialysis and cold dialysis with the stepwise ultrafiltration profile groups were 1.18 ± 0.36 and 1.44 ± 0.48, respectively, indicating that dialysis adequacy of the cold dialysis method with stepwise ultrafiltration profile was significantly higher (P = 0.001) (Table 1). Moreover, the mean and SD of pruritus scores at the beginning of dialysis in standard dialysis and cold dialysis with stepwise ultrafiltration profile using the paired samples t-test were 24.61 ± 6.47 and 24.41 ± 6.15, respectively, which revealed no significant difference ($P < 0.46$). In other words, there was no significant difference concerning the pruritus scores before starting dialysis between the two methods. Besides, the mean and SD of the pruritus scores at the end of dialysis in standard dialysis and cold dialysis with stepwise ultrafiltration profile were 23.88 ± 6.28 and 22.67 ± 5.73, respectively, which was statistically significant (P = 0.001) and indicated lower pruritus severity in patients undergoing cold dialysis with the stepwise ultrafiltration profile compared to the patients undergoing standard dialysis (Table 2). The paired-samples t-test was used to compare the pruritus scores in the standard dialysis and cold dialysis with the stepwise ultrafiltration profile. According to the findings, the mean scores of pruritus at the beginning and end of dialysis session in both standard dialysis and cold dialysis with stepwise ultrafiltration profile were -0.73 ± 0.80 and -1.73 ± 1.16, respectively, showing a statistically significant difference (P = 0.001) (Table 3), which suggests that patients treated with the dialysis solution at a lower temperature with the ultrafiltration profile felt less pruritus than the patients undergoing the standard dialysis.

5. Discussion

The current study aimed to investigate the effect of dialysis solution temperature and stepwise ultrafiltration profile on dialysis adequacy and pruritus of patients undergoing hemodialysis. The results indicated the positive effect of cold dialysis with stepwise ultrafiltration profile on both dialysis adequacy and pruritus of the hemodialysis patients. Pruritus is a common problem of patients undergoing hemodialysis (28). Studies conducted in Iran emphasized that, despite recent advancements in therapeutic options, pruritus is a major problem for hemodialysis patients. For example, a study performed in the South of Iran

Table 1. Comparison of the Mean Scores of Dialysis Adequacy in Patients Undergoing Standard and Cold Dialysis [a]

Variable	Standard Dialysis	Cold Dialysis with Stepwise Ultrafiltration Profile	P-Value [b]
Dialysis adequacy	1.18 ± 0.36	1.44 ± 0.48	0.001

[a] Values are expressed as mean ± SD unless otherwise indicated.
[b] Paired samples.

Table 2. Comparison of the Mean Scores of Pruritus in Patients Undergoing Standard and Cold Dialysis [a]

Variables	Standard Dialysis	Cold Dialysis with Stepwise Ultrafiltration Profile	P-Value
Pruritus			
Before dialysis	24.61 ± 6.47	24.41 ± 6.15	0.46
After dialysis	23.88 ± 6.28	22.67 ± 5.73	0.001
P-value [b]	0.001	0.001	-

[a] Values are expressed as mean ± SD unless otherwise indicated.
[b] Paired samples.

Table 3. The Changes in the Pruritus Scores in the Patients Undergoing Standard and Cold Dialysis [a]

Variable	Standard Dialysis	Cold Dialysis with Stepwise Ultrafiltration Profile	P-Value [b]
Mean difference	-0.73 ± 0.80	-1.73 ± 1.16	0.001

[a] Values are expressed as mean ± SD unless otherwise indicated.
[b] Paired samples.

reported that 58.3% of patients in Bandar Abbas had pruritus (7). Or another study performed in Ahvaz (Southwest of Iran) reported a similar prevalence (i.e., 58.3%) for pruritus (8). Besides, 40% of patients in Gorgan reported pruritus (5). Abbasi (2011), in a study on the prevalence of pruritus among hemodialysis patients, reported that pruritus is a common problem among those undergoing hemodialysis. Moreover, 48% of patients suffered from pruritus (27), indicating the importance of pruritus as a persistent serious problem from the patients' perspective. As pruritus control is one of the important priorities in patients' treatment programs, there should be therapeutic programs to manage pruritus. The results of the present study concerning the prevalence of pruritus, as reported by patients undergoing cold hemodialysis with the stepwise ultrafiltration profile, are consistent with those reported by Imani et al. (2018). They found that cold hemodialysis could relieve pruritus symptoms (15). However, they used only cold dialysis. Other studies also showed that pruritus is associated with factors such as hemodialysis sessions and dialysis adequacy (29-31).

For example, Malekmakan et al. (2013) studied skin pruritus and its relationship with dialysis adequacy and blood factors in hemodialysis patients and showed a significant relationship between skin pruritus and dialysis adequacy (29). Many studies have emphasized that the higher the dialysis adequacy, the lower the severity of pruritus (19, 32). However, the results of some studies are not in line with the findings of the present study (33, 34). It is believed that decreased renal function or the inadequacy of alternative therapies may result in the accumulation of waste materials in the body, which can stimulate the skin pruritus process (15). Thus, probably through improving dialysis adequacy causes decreased severity of pruritus. It worth noting that, in contrast to previous studies, in the present study, we examined a group of patients undergoing standard hemodialysis and cold hemodialysis with the stepwise ultrafiltration profile. According to the findings, patients who received cold dialysis with a stepwise ultrafiltration profile reported significantly less pruritus.

In other words, according to the evidence, cold dialysis not only created a better hemodynamic condition but also and improved the signs and symptoms of hemodialysis (e.g., hypotension and fatigue). Therefore, these patients could better remove waste products compared to those who received a standard solution or a solution at the body temperature (35). This is one of the reasons why patients reported less pruritus with cold dialysis. In many cases, one of the most common reasons for stopping hemodialysis is hemodynamic changes, which sometimes leads to a decision to stop hemodialysis, reduced duration of the treatment, declined pump speed, or replace of a smaller filter, all of which negatively affect the hemodialysis adequacy (20).

As mentioned earlier, in addition to cold dialysis, a stepwise ultrafiltration profile was also used in the present

study. In contrast to other studies, which have focused mainly on cold dialysis, these two parameters were considered simultaneously in the present study. It seems that cold dialysis not only can increase patient's tolerance but also is associated with better removal of waste products (35). The use of the stepwise ultrafiltration profile also has additional effects on waste disposal because this technique can improve dialysis adequacy by stabilizing hemodynamic variables (36, 37). According to the best knowledge of the authors, there is no previous study similar to the present study (i.e., focusing on combined administration of cold hemodialysis with the stepwise ultrafiltration profiles). Most studies have used a combination of other profiles. For example, Ghafourifard et al. (2010) examined the effect of combining two types of sodium and ultrafiltration profiles on systolic and diastolic blood pressures during dialysis in patients undergoing hemodialysis. The results showed that the sodium and stepwise ultrafiltration profiles could stabilize patients' hemodynamic conditions and blood pressure during dialysis; thus, they were different from routine dialysis (38), as the use of a stepwise ultrafiltration profile can prevent the adverse effects of dialysis, which interrupts or declines the dialysis time by stabilizing hemodynamic variables and, ultimately, results in increased hemodialysis adequacy. Furthermore, as indicated above, increasing adequacy could reduce the severity of pruritus. A study by Hamidi et al. (2019) indicated that dialysis adequacy in the stepwise method was 0.14 more than the routine method (39). Moreover, Sarbaz et al. (2019) investigated the effect of lowering hemodialysis temperature on dialysis adequacy in diabetic patients and showed that the use of cold solution increased dialysis adequacy (18). In addition to improving dialysis adequacy, this method is associated with better removal of waste products from the body. Also, after dialysis, it causes a better feeling of relief. Moreover, it is reported that urea removal leads to declined incidence of pruritus (35). Accordingly, it can be argued that cold hemodialysis increases hemodialysis adequacy by reducing the interruption periods of hemodialysis due to hypotension. The difference between the findings of the present study and other studies can be attributed to the hemodialysis solution temperature, which is effective in dialysis adequacy (18). Another positive approach of the present study is using the stepwise ultrafiltration profile with cold dialysis, which was different from other studies in terms of the research procedure and selection of variables. For example, Abbass (2007) studied 28 patients who were undergoing hemodialysis. In both groups, patients underwent hemodialysis based on fluid flow rates of 500 and 800 mL/min. According to the findings, patients who received a fluid flow rate of 800 mL/min had better dialysis adequacy (36). However, the present study was conducted on a group of patients who served as both case and control groups by strictly observing the inclusion and exclusion criteria. Furthermore, we did our best to neutralize the possible effects of confounders. Another strength of the present study is the choice of hemodialysis method. Because of time constraints, only one of the complications of hemodialysis was evaluated in the present study.

Future studies are needed to extend our knowledge about other complications of chronic renal failure in longer periods. The current study had limitations, including possible effects of numerous variables on the adequacy and pruritus of patients, which in turn have influenced the findings. In this study, we performed a preliminary study on a group of patients in order to control these factors.

5.1. Conclusions

This study demonstrated that the use of stepwise ultrafiltration profile along with lowering the temperature of hemodialysis solution (36 degrees) not only could improve dialysis adequacy but also reduced the severity of uremic pruritus. Therefore, to improve dialysis adequacy and reducing the pruritus rate and severity, the use of a simple and low-cost cold dialysis method with a stepwise ultrafiltration profile can be recommended. Further studies are needed to explore the efficacy of this method in order to increase its reliability.

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Footnotes

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