Original Article

# Impact of stepwise sodium and ultra filtration profiles and dialysis solution flow rate profile on dialysis adequacy

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## Abstract

**Background:** Inadequate dialysis is one of the main causes of mortality of the patients undergoing hemodialysis. The methods that lead to improvement of dialysis adequacy in these patients are of great importance due to them causing an improvement of quality of life. As numerous factors can play a role in improvement of dialysis adequacy, the present study aimed to investigate the level of impact of stepwise sodium and ultra filtration profiles and dialysis solution flow rate profile on dialysis adequacy.

**Materials and Methods:** This is a cross-over clinical trial conducted on 32 patients selected from two hemodialysis centers in Isfahan in 2013. The patients were assigned to two identical groups through random allocation, and each patient in group 1 underwent hemodialysis for four routine dialysis sessions, four stepwise sodium and ultra filtration profile sessions, and four sessions by stepwise dialysis solution flow rate profile. The patients in group 2 underwent hemodialysis for four sessions of stepwise dialysate flow rate profile, four sessions of stepwise sodium and ultra filtration profiles, and four sessions of routine dialysis method. Dialysis adequacy was on line calculated by *Kt*/*V* ratio in each session, and was analyzed by repeated measure analysis of variance (ANOVA), least significant difference (LSD) *post-hoc* test, and independent *t*-test.

**Results:** Means of dialysis adequacies were 1.239 (0.25) in the routine method, 1.407 (0.26) in stepwise sodium and ultra filtration profiles, and 1.414 (0.26) in dialysis solution flow rate profile. There was a significant difference between the routine method and the other two profiles ($P < 0.05$), but the difference in dialysis adequacy means in the two profile methods was not significant ($P > 0.05$). Mean scores of dialysis adequacy in the three treatment methods in the two groups showed that the sequence of methods had no effect on treatment outcome ($P > 0.05$).

**Conclusions:** Stepwise sodium and ultra filtration profiles and stepwise dialysis solution flow rate profile are suggested as they can increase dialysis adequacy compared to the routine method.

**Key words:** Adequacy of dialysis, dialysis solution flow rate, hemodialysis, Iran, nursing, sodium and ultra filtration profiles

## Introduction

Chronic renal failure refers to irreversible loss of kidney function, and in its end stage, the most common treatment given is hemodialysis.[1] The goal of hemodialysis is exiting the poisons from the body and preservation of its intracellular and extracellular combination in normal range as much as possible, which is measured by dialysis adequacy.[2] One of the methods that is used to calculate dialysis adequacy is *Kt*/V of computer software.[3,4] *K* is an index that is calculated based on urea filtration. *V* is the volume of urea distribution in body fluids, and as urea is easily distributed in all fluids of the body, *V* equals all body fluids that can vary by sex, height, and weight, and *t* is the dialysis time.[5,6] Dialysis of high adequacy not only improves quality of life but also prolongs life among these patients. Despite the advancements made in medical care and dialysis, the mortality due to lack of dialysis adequacy is yet unexpectedly high among these patients.[7,8] Based on the United States Renal Data system, each 0.1 increase in dialysis adequacy diminishes the mortality up to 7%.[9]

The factors which increase dialysis adequacy include use of high-flux filters, increasing blood flow rate, number of dialysis sessions, and increasing the transfer area of the dialyzer and dialysate flow rate.[10] Hemodialysis complications including hypotension and muscular cramps

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lead to intolerance of dialysis, causing a reduction in blood flow rate and dialysis time and, consequently, inappropriate *Kt/V* ratio.[8,11-13] Meanwhile, several studies showed that use of stepwise sodium and ultra filtration profiles can prevent complications to a larger extent and lead to improvement of dialysis adequacy.[14] On the other hand, some studies point to the disadvantages of this method, including a weight gain more that is than normal between sessions, which increases the need for ultra filtration during dialysis and results in reduction of dialysis adequacy.[15]

An increase in dialysis solution flow rate can increase the level of ultra filtration and urea distribution during dialysis.[16-19] Other researchers have worked on the increase of dialysis solution flow rate and dialysis adequacy. Their results showed that an increase in dialysis solution flow rate leads to an increase in urea distribution from blood to dialysis solution and an increase in dialysis adequacy,[10] but some other studies reported that an increase in dialysis solution flow rate over 600 ml/min has a little effect on the increase of *Kt/V* ratio and results in a 25% increase of the water consumed in dialysis.[20,21]

Some studies showed that dialysis adequacy is not appropriate in some cities in Iran[22-24] and reported lack of prescription of appropriate number of dialysis sessions and time, as well as the factors such as hypotension and the related signs occurring during dialysis as the reasons for it.[25] As other studies showed that stepwise sodium and ultra filtration profiles can reduce BP during dialysis[26] and an increase in dialysis solution flow rate can enhance ultra filtration and urea distribution levels, the researchers decided to investigate the impact of stepwise sodium and ultra filtration profiles and dialysis solution flow rate profile on dialysis adequacy.

## Materials and Methods

In the present study, 32 patients referring to two hemodialysis centers affiliated to Isfahan University of Medical Sciences and undergoing hemodialysis in 2013 were selected through convenient sampling based on the inclusion criteria, for investigation concerning the impact of stepwise sodium and ultra filtration profiles and dialysis solution flow rate profile on dialysis adequacy. After the research project was approved by the ethical committee of the University and research permission was issued in nursing and midwifery, and taking a written informed consent, sampling was started. The subjects were >18 years of age, and more than 3 months had passed from their hemodialysis indication and they have had hemodialysis by sodium bicarbonate through permanent vascular access, with no history of active hemorrhage, acute cardiac failure, and active infection.[14,20,21,27,28] If a patient developed hypotension and experienced dialysis complications during dialysis or the dialysis time was less than 4 h due to any reason, his/her data were not entered for analysis, although all subjects finished the study. After obtaining permission from the related university and hospital and through extraction of patients' baseline characteristics from their medical files, the patients meeting the inclusion criteria were enrolled in the study after they signed a written consent form. This is a cross-over clinical trial which was conducted in two sequences of dialysis session as follows:

1. First sequence with four sessions of routine dialysis method, four sessions of stepwise sodium and ultra filtration profiles, and four sessions of stepwise dialysis solution flow rate profile
2. Second sequence with four sessions of stepwise dialysis solution flow rate profile, four sessions of stepwise sodium and ultra filtration profiles, and four sessions of routine dialysis method.

The patients were assigned to two 16-subject groups through random allocation. One group was randomly selected to undergo hemodialysis through the first sequence and the other group through the second sequence. The results of three types of treatments in each group and between the groups were then compared. There was no washout period between the methods.[29] Each subject was also considered as its control in the study so that all subjects underwent three treatment methods, through which confounding factors such as body mass index (BMI), weight, sex, and vascular access were controlled. Each patient underwent hemodialysis for four sessions[21] by the routine method in which the concentration of sodium was fixed at 138 mmol/L with a fixed ultra filtration rate and a dialysis solution flow rate of 500 ml/min.

Then, they underwent dialysis for four sessions by stepwise sodium and ultra filtration profiles in which the concentration of dialysis solution sodium was initially 146 mmol/L which was reduced step by step and reached 138 mmol/L at the end of dialysis, while the ultra filtration level was reduced based on the sodium profile automatically and step by step during dialysis. Finally, they underwent four sessions of stepwise dialysis solution flow rate profile in which dialysis solution flow rate was initially 800 ml/min which automatically and in a step-by-step manner decreased to 500 ml/min at the end of dialysis. To calculate *Kt/V* ratio in each session, patients' and treatment-related data were entered in the dialysis device in each session, through which *Kt/V* was automatically calculated and recorded in the checklist, and the obtained results of each treatment method were compared. Patients' BP was measured and recorded in the checklist before, during, and after dialysis. $P < 0.05$ was considered significant. In order to have an identical intervention, all subjects underwent hemodialysis by B. Braun hemodialysis device (Dialog model) made in Germany.

The dialysis solution was sodium bicarbonate with a temperature of 36°C-37°C and a blood flow rate of 300-350 ml/min. Identical filters were used for each of the subjects during the study. The obtained data were analyzed by repeated measure analysis of variance (ANOVA), least significant difference (LSD) *post hoc*, Chi-square, and independent *t*-test in SPSS 18.

## Results

In the present study, 32 patients including 12 (32.5%) women and 20 (67.5%) men participated. The subjects were randomly assigned to two groups through random allocation. During the study, 192 dialysis sessions were held for each group (384 sessions for both groups). Mean age of the subjects was 56-62 (16.75) years. Independent *t*-test showed no significant difference in subjects' mean age between the two groups. The most common etiology in renal patients was hypertension (31.2%) and diabetes (28.1%). Chi-square test also showed no significant difference in subjects' vascular access between the two groups ($P < 0.05$). None of the subjects developed hypotension during BP measurement before, during, and after dialysis, and all subjects finished the study. There was no significant difference between the three treatment methods concerning BP measurements before, during, and after dialysis ($P < 0.05$). Repeated measure ANOVA and LSD *post-hoc* tests showed a significant difference in the mean scores of dialysis adequacy in the three treatment methods is each group. Mean score of dialysis adequacy in the routine method was 1.239 (0.25), which was less than 1.407 (0.26) in stepwise sodium and ultra filtration profiles and 1.414 (0.25) in stepwise dialysis solution flow rate profile ($P < 0.05$), but the mean scores of dialysis adequacy showed no significant difference in the two profiles ($P > 0.05$). Independent *t*-test showed no significant difference in the mean scores of dialysis adequacy in the three treatment methods between the two groups ($P > 0.05$). It can be concluded that sequence of treatment methods has no effect on dialysis adequacy [Figure 1].

## Discussion

An increase in dialysis adequacy can improve the quality of life, prolong life, increase life satisfaction, and lower mortality in end-stage renal failure patients undergoing hemodialysis. Therefore, using methods that can enhance dialysis adequacy is very essential. The obtained results showed that stepwise sodium and ultra filtration profiles and stepwise dialysis solution flow rate profile can improve dialysis adequacy in patients, compared to the routine method. Regarding stepwise sodium and ultra filtration profiles, Song *et al.*, in their study on 11 patients undergoing hemodialysis with various stepwise sodium and ultra filtration profiles, concluded that sodium stepwise profile accompanied with stepwise ultra filtration profile resulted in prevention of hypotension during dialysis, better functioning of ultra filtration, and preservation of dialysis adequacy.

In their study, complications during dialysis occurred in 18 sessions in control (54.5%) out of 33 sessions, and in stepwise sodium and ultra filtration group, they occurred in 9 sessions (27.3%) out of 33 sessions, which showed a significant difference between the two groups.[14]

Zhou *et al.*, in a study on the effect of sodium and ultra filtration profiles on hypotension in eight patients undergoing hemodialysis with a fixed concentration of sodium and sodium and ultra filtration profiles, stated that application of the latter profile can prevent osmotic imbalance of body fluids and, consequently, leads to a more stable hemodynamic status.[29]

In a study by Ghafourifard *et al.* comparing the effects of three combined methods of linear sodium profile and linear ultra filtration profile, stepwise sodium profile and stepwise ultra filtration profile, and routine method on BP changes, it was concluded that application of sodium and ultra filtration profile was a simple and cost-effective method bringing about a stable hemodynamic status in patients during dialysis.[26]

Tang *et al.* investigated the effect of sodium linear profile method in 13 patients undergoing hemodialysis and concluded that application of this method reduced hypotension during dialysis by 62%, although dialysis adequacy showed no significant difference in these sessions compared to the routine method. Different number of subjects in this study and the present study, the imposed profile, and the different number of sessions and types of

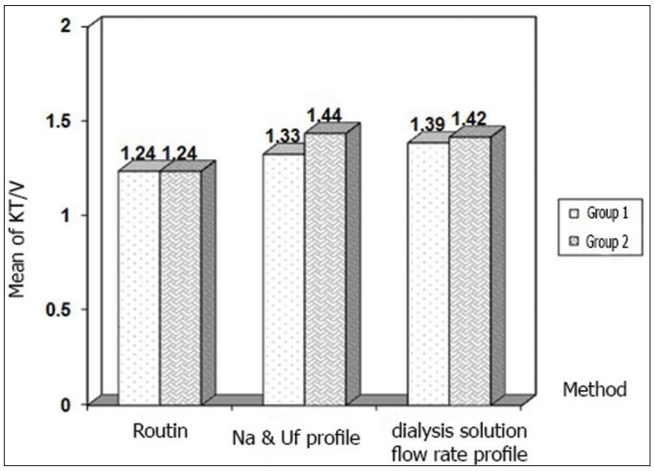


**Figure 1:** Mean of *Kt*/V in three methods in the two groups

dialysis devices can be the reasons for this difference.[15] Generally, sodium and ultra filtration profiles seem to cause patients' hemodynamic stability during dialysis, so that the patient can tolerate dialysis better and dialysis adequacy increases. Abbass, in a study on 28 patients undergoing hemodialysis based on the level of dialysis solution flow rate in two groups with dialysis solution flow rate of 500 ml/min and 800 ml/min, respectively, reported a significant difference in the mean scores of dialysis adequacy in the two groups ($P < 0.05$) as the group with 800 ml/min dialysis solution flow rate had a better dialysis quality.[10] Ouseph *et al.*, in a study on the effect of increasing dialysate flow rate on urea mass transfer area, concluded that when the level of dialysis solution increased from 500 ml/min to 800 ml/min, the filtration clearance level increased by 5.7%, and when the increase of dialysis solution was from 300 ml/min to 400 ml/min, the filtration clearance level increased by 4.1%.[28] Ward *et al.*, in a study on defining the effect of dialysate flow rate on dialysis adequacy in 42 patients undergoing hemodialysis in two groups of dialysate flow rate of 600 ml/min and 800 ml/min, respectively, showed no significant difference in the mean dialysis adequacy between the two groups[21] ($P > 0.05$), possibly due to difference in the length and number of sessions, use of different filters, and *Kt/V* ratio measurement in that study and in the present study. Azar (2009), in a study comparing dialysate flow rates of 500 ml/min and 800 ml/min with high-flux and low-flux filters, showed that dialysis adequacy increased in sessions with high-flux filters, but the mean scores of dialysis adequacy in sessions when the patients underwent hemodialysis with low-flux filters showed no significant difference.[30] Different subject numbers in the two methods of the above-mentioned study and the higher number of subjects undergoing high-flux filters could be the reasons for the different results obtained compared to present study. Hauk believes that other methods used to increase dialysis adequacy are expensive and the best option is to increase dialysate flow rate.[31] Meanwhile, Ward *et al.* believed an increase in dialysate from 600 ml/min to 800 ml/min imposes 25% increase in consumed water. Therefore, dialysis solution flow rate profile was used in the present study, so as not to fix the dialysis solution flow rate at 800 ml/min during 4 h of dialysis to economize water. In the present study, dialysis solution flow rate was initially fixed at 800 ml/min, and then reduced step by step to 500 ml/min. The results showed improvement of dialysis adequacy as dialysis solution flow rate profile is a simple method which, with a higher steep of flow, enhances urea distribution and increases the urea clearance. Increasing the dialysis solution flow rate can also increase ultra filtration leading to a better clearance of poisons in the blood, as an increase in ultra filtration level brings about poisons' shift to dialysis solution.[16,19]

## Conclusion

Generally, it can be concluded that application of stepwise sodium and ultra filtration profiles can lead to a better hemodynamic status in patients and, consequently, patients' better tolerance of hemodialysis. On the other hand, dialysis solution flow rate profile can cause more distribution of urea and a better clearance of poisons in the blood, and these two mechanisms improve dialysis adequacy. Therefore, application of stepwise sodium and ultra filtration profile and stepwise dialysis solution flow rate profile is suggested to improve dialysis adequacy. It is suggested to conduct this study with a higher sample size and more number of dialysis sessions.

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