Effect of Pre-dialysis Serum Sodium Measurement on Reduction of Hemodialysis Complications

Khadijeh Yazdi,[1] Sara Saadatmand,[2] Einollah Mollai,[1]
Maliheh Abbasi,[1] Majid Dastorani,[3] Saeid Amirkhanlou[4]

[1]Nursing Research Center, Golestan University of Medical Sciences, Gorgan, Iran
[2]5-Azar Educational and Medical Center, Golestan University of Medical Sciences, Gorgan, Iran
[3]Metabolic Disorders Research Center, Golestan University of Medical Sciences, Gorgan, Iran
[4]Department of Internal Medicine, Clinical Research Development Unit (CRDU), Shahid Sayad Shirazi Hospital, Golestan University of Medical Sciences, Gorgan, Iran

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Introduction. Despite great advances in hemodialysis, complications during dialysis remain in force. Accurate assessment of dry weight is a determining factor in the prevention of hemodialysis complications. This study is designed to evaluate the effect of adjustment of ultrafiltration rate, on hemodialysis complications, based on dry weight calculation, by measuring the pre-dialysis serum sodium.

Methods. In this single-blind clinical trial 50 patients were included. The patients were randomly divided into case and control groups. First, in the intervention group, the blood sodium level was measured before dialysis. Then, the dry weight of the patients was determined, ultrafiltration was adjusted according to the dry weight, and the patients' dialysis program was performed. In the control group, dry weight was determined routinely. Blood pressure, muscle cramps, nausea, and vomiting were recorded in both groups for 3 months.

Results. The results showed a significant difference between the two groups in the rate of postoperative nausea and vomiting ($P < .05$) and muscle cramps during dialysis ($P < .05$). There were no significant differences between the two groups in blood pressure drop during dialysis and fatigue after hemodialysis in the first, second, and third months ($P > .05$).

Conclusion. Accurate assessment of dry weight by the pre-dialysis blood sodium formula, reduces muscle cramps, nausea, and, vomiting.

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INTRODUCTION

Despite great technological and equipment advances, complications during hemodialysis are common.[1,2] Dry weight is the lowest weight that a patient can tolerate after dialysis, without causing symptoms such as hypotension, muscle cramps, nausea, and vomiting.[3] The amount of ultrafiltration is usually measured by calculating the patient's dry weight. It should be noted that the incidence of complications during hemodialysis is affected by the balance between the rate of ultrafiltration and changes in plasma volume.[4] Common complications during hemodialysis, in order of frequency, are: hypotension of about 23%, muscle cramps of about 10 to 20%, and nausea and vomiting of 10%.[5-7] Fatigue is one of the most common symptoms in patients undergoing hemodialysis, and about 60 to 90% of dialysis patients experience this complication.[8] Hypotension, occurring in 23% of hemodialysis treatments, is the

most common complication during hemodialysis. Causes of hypotension are decreased blood volume in the patient following improper control of ultrafiltration, excessive increase in ultrafiltration in patients who are not overweight, use of dialysis solution with low sodium, anemia, and eating during dialysis.[9,10] Muscle cramps occur in about 10-20% of cases during hemodialysis. This is due to changes in muscle perfusion caused by volume reduction, overestimation of dry weight, and the use of low sodium dialysis solution, known as a cramping agent.[11] To reduce these complications, it is necessary to calculate the correct dry weight of these patients. Accuracy in determining dry weight leads to the prevention of rapid changes in blood volume, thereby reducing the incidence of complications during hemodialysis.[12]

Dry weight is calculated by measuring the amount of arterial natriuretic peptide (half-life is about 2 to 4 minutes), the amount of Cyclic guanidine monophosphate, the diameter of the inferior vena cava (via echocardiography), bioimpedance (based on resistance measurement), and blood volume (by monitoring changes in hematocrit and serum protein).[13] These methods are often costly and require special equipment. However, measuring the amount of sodium, the most abundant extracellular fluid cation, can be used as an useful method for determining dry weight before dialysis. To estimate the extracellular fluid volume, it is common to use substances which are dispersed in plasma and interstitial fluid which do not readily move across cell membranes.[14] In some centers, dry weight is not measured accurately in hemodialysis patients, thereby symptoms including hypotension pressure, muscle cramps, nausea, and vomiting may frequently occur. However, there are some affordable and cost-effective methods for assessing dry weight accurately. One of them is measuring pre-dialysis sodium which can help dialysis staff in the better management of the dialysis procedure and more accurate measurement of dry weight. The dialysis machine should be adjusted to maintain fluid balance in the way that the patient experiences fewer complications during dialysis. We aimed to determine the effect of ultrafiltration regulation on some hemodialysis complications, based on dry weight calculation, by measuring blood sodium level before dialysis and take a step forward to improve patient care and the quality of hemodialysis.

MATERIALS AND METHODS

This study was a single-blind clinical trial conducted in Gorgan, Iran. Based on the available sampling method, 50 dialysis patients were selected, and randomly assigned into two groups; 25 patients were in the intervention group, and 25 in the control group. Initially, according to the one-month evaluation of patients before the start of the study, patients with complications including hypotension or muscle cramps, nausea, and vomiting, occurring more than three times in a month, were identified. Then, patients were selected according to the Inclusion and exclusion criteria. Inclusion criteria were: at least one year history of hemodialysis, adults aged 18 to 65 years old, ability to communicate verbally, with no history of diabetes mellitus, urinary incontinence syndrome, heart and liver failure, and adrenal hypertrophy, no use of antihypertensive and antispasmodic drugs four hours before dialysis, and not dependent to mechanical ventilation. Exclusion criteria were: Impaired consciousness, participant's withdrawal from the study, severe blood supply problem in the fistula or vascular access, migration or travel during the study, and death.

After explaining the aims of the research to the participants and obtaining their informed written consent, they were randomly divided into two equal groups, and matched by considering the confounding factors. Data collection instruments included social data collection forms, Seca scales for measuring the patients' weight, height and BMI, and a checklist for collecting data on dialysis complications (blood pressure, muscle cramps, Nausea, and vomiting, and whether the patient had a question or not). The mentioned parameters were evaluated and data were recorded every hour. A 10-point visual analogue scale was used to assess fatigue. Blood pressure was measured before, every hour during dialysis, and at the end of dialysis by a pressure gauge cuff connected to the dialysis machine after calibration, in a semi-sitting position. A blood sample was obtained before dialysis. To measure the serum sodium level before dialysis, a bio-life device and a bio pier kit (a special kit for a bio-life device made in Taiwan) was used.

According to the following formulas, actual

body water (ABW) is first calculated on the basis of pre-dialysis serum sodium level and normal total body water (NTBW). Then, the difference of NTBW from the calculated ABW is used as the basis of ultrafiltration.[15-17]

Excess fluid in the patient's body = NTBW - ABW

Dry weight = patient weight - excess fluid in the patient's body

Dry weight = patient's weight - (NTBW - ABW)

Actual body water in liters = 142 × NTBW/pre-dialysis serum sodium

In this method, excess fluid in the patient's body is assumed to be the ultrafiltration needed for each hemodialysis session.

According to the dry weight, the amount of ultrafiltration was adjusted and the patient's dialysis program was carried out. In the control group, dry weight was determined by trial-and-error method depending on the general condition of the patient after dialysis and the absence of hypotension and muscle cramps in the previous sessions. Then both groups were followed and complications were recorded[17] for 36 sessions of hemodialysis (three sessions per week) in 3 months.

All Helsinki ethics were observed in this study. Necessary explanations were given to all patients and their informed written consent was obtained. All information about patients would remain confidential and codes or file numbers were used instead of names to observe the confidentiality of the recorded information. The patients were informed that they could withdraw from the study at any time during the course of the study. Ethical permission to conduct this research was obtained from the Regional Committee of Medical Ethics of Golestan University of Medical Sciences (IR.goums.rec.1394.8). This study was registered on the clinical trial site with IRCT code 2015042318649N2.

RESULTS

The number of patients participating in the study was 50. One patient was excluded due to a long travel. Out of 49 patients remaining in the study, 20 were men (40.8%) and 29 were women (59.2%).

The age range of the participants was 19-65 with the mean of 52.55 ± 11.13. Dry weight in the first month of the study ranged from 30.44 kg to 99 kg (67.90 ± 15.78), in the second month of the study, from 31 kg to 98.200 kg (67.15 ± 15.86), and in the third month of the study from 31 kg to 99 kg (67.47 ± 15.82) (Table 1). Other demographic data of patients are shown in Table 1. The blood flow rate ranged from 200 to 300 mL/min. Dialyzers used in this study were High Flux with an ultrafiltration coefficient between 40 and 55.

Among the participants in the intervention group, 45.2% and in the control group 54.8% had no nausea or vomiting in the first month of the study. Fisher's exact test showed that the two groups were significantly different in terms of nausea and vomiting in the first month of the study ($P < .05$).

In the second month of the study, 53.8% of the subjects in the intervention group and 46.2% of the subjects in the control group had no nausea or vomiting. Fisher's exact test showed that there was a significant difference between the two groups in terms of nausea and vomiting in the second month of the study ($P < .05$).

Table 1. Central Indices and Dispersion of Quantitative Traits

Variables	Number	Minimum	Maximum	Medium	Standard Deviation
Age, y	49	19	65	52.55	11.13
Height, cm	49	131	185	158.38	12.07
History of Dialysis, y	49	12	216	48.38	67.97
Pump Speed, milliseconds	1764	200	300	253.76	9.91
Filter Ultrafiltration Coefficient	1764	40	55	6.53	1.10
The Dry Weight of the First Month	49	30.400	99	67.90	15.78
The Dry Weight of the Second Month	49	31	99.20	67.15	15.86
The Dry Weight of the Third Month	49	31	99	67.47	15.82
Sodium Level Before Dialysis in the First Month, milliequivalents/L	49	133	145	138.16	2.96
Sodium Level Before Dialysis in the Second Month, milliequivalents/L	49	133	144	138.4	2.7
Sodium Level Before Dialysis in the Third Month, milliequivalents/L	49	131	146	138.2	2.96

In the third month, 51.4% of the participants in the intervention group and 48.6% of in the control group had no nausea or vomiting. Fisher's exact test showed that there was a significant difference between the two groups in terms of nausea and vomiting in the third month of the study ($P < .05$) (Table 2).

Among the participants of the study, 65.5% in the intervention group and 35% in the control group had no muscle cramps in the first month. Chi-square test showed that the two groups were significantly different in terms of muscle cramps in the first month of the study ($P < .05$). In the second month, 70.4% of the participants in the intervention group and 29.6% of them in the control group had no muscle cramps. The two groups were significantly different in terms of muscle cramps in the second month of the study ($P < .001$). In the third month, 61.5% of the participants in the intervention group and 38.5% of them in the control group had no muscle cramps. The two groups were significantly different in terms of muscle cramps in the third month of the study ($P < .001$) (Table 2).

In our study, 54.5% of the participants in the intervention group and 45.5% of them in the control group showed complications of hypotension in the first month. Chi-square test showed that there was no significant difference between the two groups in terms of blood pressure drop in the first month of the study ($P > .05$). In the second month, 57.7% of the participants in the intervention group and 42.3% of the participants in the control group had no complications of hypotension and there was no significant difference between the two groups in terms of blood pressure drop in the second month of the study ($P > 0.05$).

In the third month of the study, 54.2% of the participants in the intervention group and 45.8% of the participants in the control group had no complications of hypotension and there was no

Table 2. Comparison of Complications During Dialysis by Case Group and Control Group in the First, Second, and Third Month

Complication	By Month	Studied Groups	Have (%)	Doesn't Have (%)	*P*
Rate of Nausea and Vomiting	First Month	Case Group	57.1	45.2	> .05
		Control Group	42.9	54.8	
	Second Month	Case Group	20	53.8	< .05
		Control Group	80	46.2	
	Third Month	Case Group	30	51.4	0.05
		Control Group	70	48.6	
Muscle Cramp Rate	First Month	Case Group	34.5	65.5	< .05
		Control Group	65	35	
	Second Month	Case Group	18.2	70.4	< .001
		Control Group	81.4	29.6	
	Third Month	Case Group	41.7	61.5	< .001
		Control Group	58.3	38.5	
The Rate of Hypotension	First Month	Case Group	40.7	54.5	> .05
		Control Group	59.3	45.5	
	Second Month	Case Group	34.8	57.7	> .05
		Control Group	62.2	42.3	
	Third Month	Case Group	40	54.2	> .05
		Control Group	60	45.8	
The Rate of Hypertension	First Month	Case Group	50	36.4	> .05
		Control Group	50	63.6	
	Second Month	Case Group	48.8	37.5	> .05
		Control Group	51.2	62.5	
	Third Month	Case Group	50	42.9	> .05
		Control Group	50	57.1	
Fatigue Rate	First Month	Case Group	1.75 ± 0.71		> .05
		Control Group	2.06 ± 0.68		
	Second Month	Case Group	1.59 ± 0.69		> .05
		Control Group	1.94 ± 0.77		
	Third Month	Case Group	1.35 ± 0.51		> .05
		Control Group	1.55 ± 0.50		

significant difference between the two groups in terms of blood pressure drop in the third month of the study ($P > .05$) (Table 2).

In addition, 34.4% of the participants in the intervention group and 63.6% of the participants in the control group had no hypertension in the first month. Chi-square test showed that there was no significant difference between the two groups in terms of hypertension in the first month of the study ($P > .05$).

In our study, 37.5% of the participants in the intervention group and 62.5% of the participants in the control group had episodes of hypertension in the second month and there was no significant difference between the two groups in terms of hypertension in the second month of the study ($P > .05$).

In the third month, 42.9% of the participants in the intervention group and 57.1% of the participants in the control group had no complications of hypertension. There was no significant difference between the two groups in terms of hypertension in the third month of the study ($P > .05$) (Table 2).

Regarding fatigue, Mann-Whitney test showed no significant difference between the two groups in the first month ($P > .05$). Moreover, there was no significant difference between the two groups in the second and third months in terms of fatigue ($P > .05$) (Table 2).

DISCUSSION

Although the invention of dialysis machines dates back several decades, and we have gained considerable experience in hemodialysis methods, adjusting the ultrafiltration of the dialysis machine according to the patient's dry weight is a challenge.

Due to lack of sufficient urine, presence of cardiovascular disease, and other co-morbidities, it is difficult to calculate the most appropriate weight for a patient undergoing hemodialysis with the usual methods employed in hemodialysis departments. Determining the appropriate weight or dry weight of patients is not usually done according to a specific method in hemodialysis departments. The aim of this study was to investigate the effect of calculating dry weight and ultrafiltration based on predialysis sodium on some complications of hemodialysis. Although there are other accurate methods for calculating dry weight, this method is easy to apply in a short period and is not costly nor demanding for the patient.

The findings of the study showed that there was no significant difference between the two groups in terms of nausea and vomiting, and cramps during dialysis in the first month. However, the findings showed a significant difference between the intervention and control groups in the second and third months of the study. The result of the current study showed that there was no significant difference between the two groups regarding blood pressure and fatigue, in the first, second, and third months of the study. Assessing dry weight accurately is a time-consuming process, which might be responsible for the lack of a significant relationship in the first month; while as the patient reaches the desired dry weight, the distressing symptoms improve. However, this improvement was not significant for blood pressure-related complications. These findings are not in line with the findings of the study by Sangiz *et al.* who showed a reduction in systolic and diastolic blood pressure.[18] In our study, there was no change in the incidence of decreased or increased blood pressure. This can be because many patients with kidney failure primarily have hypertension or atherosclerosis. In another study, Chuchen *et al.* showed that extracellular fluid volume should be assessed to determine the dry weight and correct their blood pressure in patients with hypertenion.[19] They also added if patients with normal blood pressure, show complications during hemodialysis, their higher dry weight should be considered until the symptoms disappear during hemodialysis or their blood pressure increase[19]. The results of this study were consistent with the results of our study in terms of reducing some complications such as muscle cramps but were inconsistent with the results of our study in terms of blood pressure control due to the different method used to determine dry weight. There is no consensus on how much a reduction in blood volume causes symptoms of hypotension in patients; as different patients do not have the same reactions to a reduction in blood volume. Some patients tolerate changes of up to 20% in blood volume. Some researchers challenge the calculation of blood compositions through anthropometric calculations; thus, more studies are needed in this regard.[20]

The results of the study conducted by Hamidi *et al.* were in line with the results of our

research which showed a significant decrease in the incidence of complications and the number of treatment measures in the linear and stepwise sodium-ultrafiltration method as compared to the routine method. In our study, hypotension was not significantly different in the three- month period. Borzoo *et al*. showed that the incidence of hypotension in the sodium-ultrafiltration linear profile method was significantly lower ($P < .05$) as compared to the conventional method and the comfort in the sodium-ultrafiltration linear profile method was higher; however, the incidence of muscle cramps was higher. Also in their study, muscle cramps were not significantly different in the two methods[21] while in the present study, the complication of muscle cramps was significantly reduced in three months. If the patient can prevent excessive weight gain by reducing water and salt intake between hemodialysis sessions, the need to take fluid from the patient during hemodialysis is reduced, resulting in a reduced risk of hypovolemia, hypo-osmolarity, and eventually muscle cramps.[22]

Therefore, reducing complications via using this method, the quality of dialysis can be increased and by increasing the comfort of patients during dialysis, their satisfaction can be increased and the workload of staff can be reduced so they can provide quality care to patients during dialysis. It should be noted that the use of visual tools to determine the degree of fatigue was one of the limitations of this study.

Our suggestion for future studies is to compare the adjustment of ultrafiltration rate based on the method of dry weight determination through monitoring blood volume during dialysis, using the pre-dialysis sodium dry weight determination method. Our study showed that some of the important complications of hemodialysis related to dry weight were reduced with the method of calculating ultrafiltration in terms of serum sodium before hemodialysis. This reduction in complications was also statistically significant for muscle cramps, nausea, and vomiting. Regarding the rate of weakness and lethargy, although the difference was not statistically significant, the average rate of fatigue in the intervention group was lower than the control group. This is clinically important because the patient would be healthier and able to do their daily activities, thereby improving their quality of life. However, the findings of this study did not show a reduction in the incidence of hypertensive disorders (decrease or increase in blood pressure) during dialysis.

COCLUSION

Overally, our study showed adjusting the amount of ultrafiltration based on the calculation of dry weight through measuring the amount of sodium before dialysis is a simple and low-cost method reducing the incidence of some complications such as muscle cramps, nausea and vomiting during dialysis. To reduction in the incidence of these complications, the ultrafiltration rate can be adjusted by using this method. In particular, patients for whom we are unable to solve the complications of muscle cramps, nausea, vomiting, weakness and fatigue caused by conventional measures, will benefit from this method.

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Correspondence to:
Saeid Amirkhanlou, MD
Associate Professor of Nephrology, Department of Internal Medicine, Clinical Research Development Unit (CRDU), Shahid Sayad Shirazi Hospital, Golestan University of Medical Sciences, Gorgan, Iran
E-mail: drsam74ir@ymail.com

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