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Original Article

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Potassium Removal by Predilution Online Hemodiafiltration Compared with Conventional Hemodialysis

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ABSTRACT

Background: Potassium balance is an important concern of nephrologists when treating patients on dialysis. However, the amount of potassium removed by predilution online hemodiafiltration has not been investigated in prior studies. The purpose of the study was to investigate the amount of potassium removed by predilution online hemodiafiltration compared to conventional hemodialysis.

Methods: This study traced the amount of potassium removed in each session among 23 patients undergoing both conventional hemodialysis and predilution online hemodiafiltration. The effect of the concentration of potassium and bicarbonate in the dialysate was evaluated. Finally, the influence of β-blocker use on potassium homeostasis was also assessed.

Results: There was no difference in mean serum potassium levels between conventional hemodialysis and predilution online hemodiafiltration [P = NS (nonsignificant)] before and 1 hour after the end of the session (P = NS). Significantly less potassium was removed in conventional hemodialysis compared to predilution online hemodiafiltration ($P < .0001$). The amount of potassium removed in conventional hemodialysis was lower in the high potassium dialysate group ($P < .02$) and in those undergoing predilution online hemodiafiltration ($P < .03$). The use of β-blockers was associated with higher predialysis serum potassium levels in the group of conventional hemodialysis.

Conclusion: The present study shows that in predilution online hemodiafiltration, much more potassium is removed than in conventional hemodialysis. Potassium removal is greater with low potassium dialysate in both methods. The use of β-blockers is associated with higher predialysis serum potassium levels in conventional hemodialysis, while dialysate bicarbonate concentration does not substantially affect the amount of potassium removed during dialysis.

Keywords: Dialysate, hemodiafiltration, hemodialysis, high-flux, potassium, predilution

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INTRODUCTION

Potassium balance is an important issue in the treatment of hemodialysis patients. Disorders in potassium balance can lead to sudden death and increased mortality. Whereas prior studies have quantified the amount of potassium removed in a conventional hemodialysis session, albeit with large variations,[1-4] there is no information on other dialytic methods, such as predilution online hemodiafiltration (HDF). Second, the established belief that conventional hemodialysis better removes low-molecular-weight toxins and molecules,[5] while online HDF removes those of medium-molecular-weight is not supported by solid and robust evidence.[6] Third, several investigators who measured the potassium removed in 1 dialysis session did not include a state-of-the-art methodology. In several studies, the potassium removal in the total ultrafiltrate was not assessed. Most prior studies did not obtain postdialysis blood samples to ensure the equilibration of potassium in body compartments. Finally, the adherence of dialysis patients to a potassium-restrictive diet is typically low, especially in our country during the period of summer. This is another important contributor to the high prevalence rates of hyperkalemia in the dialysis population. The purpose of the study was to investigate the amount of potassium removed by online HDF compared to conventional hemodialysis.

MATERIAL AND METHODS

Patients

We studied 23 chronic hemodialysis patients (13 males and 10 females) with a median age of 69 (range: 48-85 years) to determine how much potassium they lost in 1 predilution online HDF session compared to a session of conventional hemodialysis. The patients have been on chronic dialysis for 104.8 ± 120.9 months (range: 9-441). Only 4 out of 23 patients had residual diuresis (500, 750, 1000, and 1200 mL of urine/24 h on the interdialytic day), with creatinine clearance of 3.1, 2.8, 2.7, and 2.3 mL/min, respectively. The primary cause of kidney failure was diabetes mellitus in 5 patients, glomerulonephritis in 6 patients, hypertensive nephrosclerosis in 3 patients, polycystic kidney disease in 4 patients, and chronic pyelonephritis in 1 patient. In the remaining 4 patients, the etiology of kidney failure was unknown. With respect to vascular access, 12 patients had fistulas, 5 had a graft, and 6 had a central permanent double lumen venous dialysis catheter.

All patients were stable and uncomplicated during their dialysis sessions, and none had hemodynamic instability. All had stable dry weight for at least 3 months. None had malignancy, acute catabolic, or infectious disease. There was no evidence of gastrointestinal bleeding. None had any level of metabolic acidosis or very high blood urea concentrations. All followed a fixed diet before and during the study, which contained approximately 60 mmol of potassium/24 h.[7] Study participants were given dietary recommendations on a regular basis (along with diet manuals in simplified language understandable by each patient). Of the 23 patients enrolled, 19 were being treated with β-blockers (16 selective and 3 nonselective). All patients were informed and gave written consent for their participation in the study. This study was approved by the Scientific Council of the General Hospital of Komotini University, Komotini, Greece (protocol number 4/2022, date September 13, 2022) and was conducted in accordance with the guidelines for good clinical practice and ethical principles of the Declaration of Helsinki.

Methods

All patients underwent 1 session of conventional hemodialysis (group A) and 1 session (next week) of predilution online HDF (group B) session, with 50% of blood pump as substitution volume (48 L/session), during the midweek days (Wednesday–Thursday). The filter in both sessions was polyethersulfone (polynephron) with a surface area of 2.1 m^2 (low flux in group A and high flux in group B). The blood flow was 400 mL/min overall in both sessions, the dialysate flow was 500 mL/min, and the duration of the sessions was 4 hours or longer (in 18 patients, 4 hours; in 3, 4 hours and 15 minutes; in 1, 4 hours and 30 minutes; and in another, 4 hours and 45 minutes). As effluent volume in predilution HDF, we used 50% of the blood flow (it was 400 mL/min in all the patients), which ranged from 10.786 to 12.000 mL/h (Table 1). During dialysis, 2500 or 3500 IU of molecular weight heparin (vemiparin) were used, depending on body weight. Nikkiso DBB EXA dialysis machines were used.

The prescription of dialysate was personalised. Of the patients, 13 had 138 mmol/L of sodium, and 10 had 140 mmol/L. Dialysate bicarbonates ranged from 30-33 mmol/L, where 2 had 30 mmol/L, 5 had 31 mmol/L, 1 had 32 mmol/L, and the remaining 15 had 33 mmol/L (Table 1). The dialysate for all patients contained 3 mmol/L of acetate. Dialysate potassium was measured as 2 mmol/L in 10 patients and 3 mmol/L in the remaining 13. In all, dialysate chloride was 110 mmol/L, magnesium 0.50 mmol/L and glucose 5.5 mmol/L, both in conventional hemodialysis and predilution online HDF (Table 2). All tests were performed with a dialysate of fixed composition for each patient.

The total ultrafiltrate was collected from each patient in each of the 2 dialysis sessions in a custom-made volumetric stainless barrel (Table 1). After the end of each session and after stirring the ultrafiltrate for 10 minutes with an electric stirrer, a sample was taken for urea, creatinine, and potassium. Both at the beginning of each session and 1 hour after its end, a blood sample was taken for the determination of the same parameters from the arterial line.

To calculate the potassium in the ultrafiltrate, a modified version of the equation introduced by Blumberg et al was used (the values were given by the lab without the need for a correction

MAIN POINTS

- The existing studies do not clarify the amount of potassium removed by a session of conventional hemodialysis. In this study, the amount of potassium lost in a conventional hemodialysis session was assessed more properly by measuring the potassium in the total ultrafiltrate (it was about 100 mEq/session).
- There was no information in the literature regarding the amount of potassium removed in a session of predilution online hemodiafiltration. This is the first study to determine the potassium removal with this dialytic method. Our analysis showed the potassium removal was 2-fold higher with predilution online hemodiafiltration than with conventional hemodialysis.
- The established belief that conventional hemodialysis better removes low-molecular-weight toxins and molecules, while hemodiafiltration is superior in removing medium-molecular-weight toxins, requires further investigation. In fact, in this study, the urea reduction ratio in conventional hemodialysis and in online hemodiafiltration was similar.

Table 1. It contains the serum HCO_3^- before HD and online HDF and potassium removed during HD and online HDF, ultrafiltrate/h of HD and online HDF, body surface area, duration of sessions (HD and online HDF), predilution effluent, and URR and Kt/V (in HD and online HDF)

Patient	Serum HCO_3^- Before HD (mmol)	Potassium Removed with HDF (Predilution) (mmol)	Serum HCO_3^- Before HDF (Predilution) (mmol/L)	Potassium Removed with Conventional HD (mmol)	Ultrafiltrate (L/h)		Body Surface Area (m²)	Duration of Dialysis Session (both HD and HDF) (hour)	Predilution Effluent Volume (mL/h)	URR		Kt/V	
					HD	Online HDF				HD	Online HDF	HD	Online HDF
1	21.5	177.6	22.5	41.0	30.38	42.00	1.95	4.00	12.000	66.2	69.2	1.24	3.22
2	24.0	189.6	24.5	71.0	31.13	44.75	2.09	4.00	12.000	61.9	66.5	1.09	1.2
3	21.5	336.0	23.8	65.0	29.57	41.64	1.80	4.15	11.566	75.2	74.7	1.58	3.85
4	22.5	162.8	23.0	66.0	29.64	38.91	2.02	4.15	11.566	63.6	66.9	1.19	2.75
5	23.2	205.0	23.7	49.0	31.00	42.85	2.18	4.00	12.000	51.5	59.8	0.82	2.2
6	22.2	167.0	22.5	29.0	31.38	42.50	1.84	4.00	12.000	74.5	76.4	1.56	3.73
7	22.0	194.0	20.8	74.0	31.00	42.00	2.03	4.00	12.000	67.2	69.4	1.27	2.83
8	21.0	56.0	22.0	60.7	30.05	40.49	1.72	4.15	11.566	73.5	77.1	1.52	4.07
9	21.0	154.2	23.2	92.0	31.92	42.85	2.00	4.00	12.000	73.6	63.3	1.53	2.69
10	22.5	308.0	21.0	51.6	31.15	42.00	1.92	4.00	12.000	77.6	68.1	1.70	3.00
11	22.3	305.0	25.8	67.0	28.87	39.52	1.70	4.15	11.566	76.5	78.2	1.60	4.35
12	21.2	237.0	21.0	148.9	30.37	39.75	1.80	4.00	12.000	66.3	65.5	1.22	2.69
13	23.0	211.0	22.2	41.0	30.85	43.75	1.70	4.00	12.000	71.4	72.7	1.45	3.95
14	22.0	201.0	21.5	72.5	30.44	43.63	1.95	4.15	11.162	71.6	72.4	1.51	3.63
15	23.0	163.5	22.0	34.9	30.38	41.89	1.91	4.00	12.000	75.2	76.2	1.58	3.43
16	24.0	184.0	22.5	53.0	30.38	43.25	1.95	4.00	12.000	70.8	70.7	1.38	3.04
17	21.6	255.0	22.0	120.0	28.10	42.25	1.76	4.45	10.786	75.8	73.4	1.61	3.90
18	22.0	170.0	23.0	53.0	30.36	42.32	1.64	4.00	12.000	74.0	69.9	1.55	3.56
19	21.8	139.5	23.0	92.0	30.75	42.75	1.70	4.00	12.000	77.1	79.4	1.72	4.07
20	24.0	211.0	24.0	83.8	30.00	41.25	1.62	4.00	12.000	72.8	73.9	1.56	4.41
21	24.5	201.0	22.0	91.5	32.25	43.25	1.90	4.00	12.000	69.6	67.5	1.37	3.03
22	23.0	290.0	24.0	59.0	31.15	42.50	1.49	4.00	12.000	78.9	78.0	1.76	4.59
23	22.0	314.4	22.0	86.4	31.00	42.75	1.79	4.00	12.000	75.9	74.4	1.67	3.70
Mean ± SD		210 ± 64.8		69.7 ± 27.1	30.53 ± 0.89	42.06 ± 1.32				71.3 ± 6.2	71.5 ± 5.0	1.46 ± 0.22	3.38 ± 0.77
		$P < .0001$								P = NS		$P < .0001$	

HD, hemodialysis; HDF, hemodiafiltration; NS, nonsignificant; URR, urea reduction ratio.

factor): $K_{ultrafiltrate} = V_{ultrafiltrate} \times (K_{ultrafiltrate} - K_{dialysate})$ [$K_{ultrafiltrate}$ = potassium concentration in ultrafiltrate, $V_{ultrafiltrate}$ = volume of ultrafiltrate, $K_{dialysate}$ = potassium concentration in dialysate].[2]

An Abbott Alinity C analyzer was used to measure the studied parameters. Urea was determined with an enzymatic method, creatinine with kinetics, and potassium with an ion-selective electrode.

Statistical Analysis

Continuous variables were expressed as mean ± standard deviation (mean ± SD) or median (range), according to the normality of the distribution of each variable. Categorical variables were expressed as absolute frequencies and percentages. Comparisons between the groups of conventional hemodialysis and predialysis online HDF were performed using the student's t-test. The analysis was conducted with the statistical software MedCalc (version 20.218). Probability values of $P < .05$ (2-tailed) were considered statistically significant for all comparisons.

RESULTS

The dialysis clearance provided was assessed by the urea reduction ratio (URR), which was 71.3 ± 6.2 with conventional hemodialysis and 71.5 ± 5.0 (*P* = NS) with predilution online HDF (Table 1). Thus, in both dialytic modalities, the clearance of urea was adequate (Table 2).

Serum potassium levels before the beginning of the sessions were found to be significantly higher in predilution online HDF compared to conventional hemodialysis (6.2 ± 0.7 vs. 5.2 ± 0.7 mmol/L, $P < .0001$). In contrast, there was no significant difference between the 2 dialytic methods in the serum potassium levels 1 hour after the end of the session (4.0 ± 0.5 vs. 4.1 ± 0.5 mmol/L, *P* = NS). Significantly less potassium was removed in conventional hemodialysis compared to predilution online HDF (69.7 ± 27.1 vs. 210.0 ± 64.8 mmol, $P < .0001$) (Table 1).

Based on the dialysate potassium concentration, study participants were classified into 2 subgroups: A1 (n = 13), which had 3 mmol/L of potassium, and A2 (n = 10), which had 2 mmol/L of potassium. No significant difference in serum potassium was found between the groups in conventional hemodialysis before the beginning of the sessions (5.4 ± 0.64 vs. 4.9 ± 0.7 mmol/L, *P* = NS), while significantly higher serum potassium levels were found 1 hour after the end of the sessions in group A1 (4.2 ± 0.3 vs. 3.8 ± 0.5 mmol/L, $P < .02$). In addition, less potassium was removed in group A1 compared to the low-potassium group (58.0 ± 20.3 vs. 84.8 ± 27.3 mmol, $P < .02$). Regarding predilution online HDF, serum potassium levels in group A1 did not differ from those of group A2 (5.4 ± 0.7 vs. 5.2 ± 0.6 mmol/L, *P* = NS) before the beginning of the sessions or 1 hour after the end of the sessions (4.2 ± 0.5 vs. 4.0 ± 0.4 mmol/L, *P* = NS), but the amount of potassium removed was significantly higher in group A2 (244.5 ± 62.4 vs. 183.7 ± 53.3 mmol, $P < .03$).

The patients were further divided into groups according to whether they were receiving (group A3, n = 19) or not receiving (group A4, n = 4) a β inhibitor. Of the former group, 16 were receiving selective and 3 were receiving nonselective inhibitors. In conventional hemodialysis, significantly higher serum potassium levels were found in group A3 before the sessions (5.3 ± 0.7 vs. 4.4 ± 0.2 mmol/L, $P < .03$) as well as 1 hour after the sessions (4.1 ± 0.4 vs. 3.5 ± 0.4 mmol/L, $P < .02$), while no significant difference was found between the 2 groups in the potassium removed (65.0 ± 22.4 vs. 91.7 ± 35.2 mmol/L, *P* = NS). Regarding predilution online HDF, no difference was found in serum potassium levels before the beginning of the sessions and 1 hour after their end or in the amount of potassium removed (*P* = NS in all cases).

Dividing the patients into those with 33 mmol/L of dialysate bicarbonate (group A5, n = 14) and those with 30-32 mmol/L (group A6, n = 9), no significant difference was found in serum potassium levels 1 hour before and after sessions or in the potassium removed in both conventional and predilution online HDF (*P* = NS in all cases).

DISCUSSION

In patients undergoing hemodialysis, a potassium diet of only 51-77 mmol/24 h (2-3 g/24 h) is recommended.[8] The potassium is removed mainly through the hemodialysis filter[9] and up to 30% through the feces.[10]

Potassium disturbances before, during, and after hemodialysis sessions are very common electrolyte disorders that can cause arrhythmia. Predialysis hyperkalemia is common and dangerous, but hypokalemia during and after dialysis is also associated with increased mortality.[7] Dialytic removal of potassium plays a key role in maintaining serum potassium concentrations within a normal range. During the dialysis session, several factors may influence the removal of potassium, such as drugs,[11] dialysate glucose,[12] and bicarbonates;[4,12] the presence and the correction of acidosis;[13,14] the duration of the dialysis session;[14] and, most importantly, the dialysate potassium bath.[2,14]

There is no consensus regarding the ideal potassium concentration in the dialysate, which explains the wide variation in the prescription of dialysate potassium. Globally, however, 2.0-2.5 mmol/L of dialysate potassium is most often used.[15]

Basile et al studied potassium removal in 11 hemodialyzed patients without the collection of total ultrafiltrate.[14] These authors and other prior studies found that this amount depended mainly on the gradient of potassium between the blood and dialysate.[2,12,14] Zehnder et al studied 12 hemodialysis patients and showed that the dialytic potassium removal was dependent on the potassium concentration in the dialysate. In detail, the study used different dialysate potassium concentrations (0, 1, and 2 mmol/L) but a fixed bicarbonate concentration

Table 2. It contains the dialysate concentration of HCO_3^- (mmol/L) and potassium (mmol/L), and serum concentration of potassium (mmol/L) before and 1 hour after the end of sessions of conventional hemodialysis and predilution online HDF. Also shown the amount of potassium removed in each of the methods in 1 session

			Conventional Hemodialysis (A)			Predilution Online HDF (B)		
P's	Dialysate HCO_3^-	Dialysate Potassium	Serum Potassium (pre)	Serum potassium (1 hour After the End)	Potassium Removed/ Session	Serum Potassium (pre)	Serum Potassium (1 hour After the End)	Potassium Removed/ Session
1	33	3	5.0	4.5	41.0	5.3	4.5	177.6
2	33	2	4.9	3.7	71.0	4.8	3.8	189.6
3	32	2	4.2	3.6	65.0	6.0	4.5	336.0
4	33	2	5.6	3.9	66.0	4.6	3.7	162.8
5	31	3	5.1	4.5	49.0	5.6	5.0	205.0
6	33	3	4.5	3.8	29.0	5.2	3.8	167.0
7	31	3	4.9	4.2	74.0	4.4	4.0	194.0
8	31	3	5.5	4.3	60.7	5.6	4.0	56.0
9	30	2	4.2	3.2	92.0	4.8	3.2	154.2
10	31	3	4.5	3.9	51.6	4.4	3.8	308.0
11	33	2	4.5	3.3	67.0	5.5	4.0	305.0
12	33	2	4.6	4.1	148.9	4.1	4.2	237.0
13	33	3	5.2	4.2	41.0	5.6	4.3	211.0
14	33	2	4.7	3.6	72.5	4.8	4.1	201.0
15	31	3	5.5	3.7	34.9	5.7	4.1	163.5
16	33	3	4.7	4.3	53.0	4.8	4.3	184.0
17	31	2	5.8	4.1	120.0	5.5	4.0	255.0
18	33	3	6.3	4.3	53.0	6.1	4.8	170.0
19	33	3	6.2	4.0	92.0	4.8	3.2	139.5
20	33	3	6.5	4.9	83.8	6.8	4.9	211.0
21	30	3	5.7	4.1	91.5	5.6	4.3	201.0
22	33	2	4.4	3.2	59.0	5.6	3.9	290.0
23	33	2	6.3	4.9	86.4	6.2	4.9	314.4
Mean ± SD			5.2 ± 0.7	4.0 ± 0.5	69.7 ± 27.1	6.3 ± 0.7	4.1 ± 0.5	210.0 ± 64.8
P			(A-B) < .0001	(A-B) = NS	(A-B) < .0001			

HDF, hemodiafiltration.

(40 mmol/L). Patients underwent hemodialysis with high-flux polysulfone dialyzers that had a surface area of 1.8 m^2. The blood flow rate was 300 mL/min, and the dialysate flow rate was 500 mL/min. The dialysate did not contain glucose. The duration of each dialysis session was 4 hours. All study participants were receiving low doses of β-blockers.[12] Potassium removal was found to be 117.1 mmol with 0 mmol/L potassium in dialysate, 80.2 with 1 mmol/L dialysate potassium, and 63.3 with 2 mmol/L potassium in dialysate. These differences were statistically significant ($P < .001$).

The Na^+–K^+ ATPase pump plays a dominant role in the distribution of potassium between intracellular and extracellular spaces. In the treatment of hyperkalemia, nonselective β inhibitors are known to inhibit the movement of potassium intracellularly through downregulation of the action of Na^+–K^+ ATPase.[11] In the present study, patients receiving β-blockers had significantly higher serum potassium levels before and 1 hour after the end of conventional hemodialysis ($P < .02$). It has be noted that 16 of these patients were receiving a selective β inhibitor at low doses. Despite the fact that selective β-blockers have been reported to exert a minimal effect on the activity of Na^+–K^+ ATPase, the predialysis and postdialysis serum potassium levels in this subgroup of patients were still significantly higher than in nonusers.[16] Other patients receiving low doses of β inhibitors and undergoing conventional hemodialysis exhibited a potassium removal of around 100 mmol/session,[12] as we also found.

In the present study, it is rather difficult to explain how the potassium balance was maintained in most of the patients, despite the relative low potassium removal during conventional hemodialysis. One plausible explanation could be the compensatory larger loss of potassium through the feces, since the rate of hyperkalemia in our patients was extremely low.[10] As for the potassium removed by predilution HDF, which was more than by conventional HD, we believe this was due to the many liters of substitution fluid used, which contains significantly less potassium than the serum potassium it replaces.

Alkalosis enhances the activity of Na^+–K^+ ATPase. The exposure of a patient to increased concentrations of bicarbonates in the dialysate leads to a large gradient between the dialysate and the blood, resulting in rapid changes in blood bicarbonates and the appearance of arrhythmia due to a decrease in serum potassium.[4,17] In fact, a higher concentration of bicarbonates in dialysate is associated with a greater reduction in serum potassium levels than a low concentration, without substantial impact on the total amount of potassium removed.[4]

Heguilen et al studied the amount of potassium removed (collecting the total ultrafiltrate) in 8 hemodialysis patients during a 4-hour conventional hemodialysis session. The purpose of this study was to explore whether this amount varied according to the concentration of bicarbonates in the dialysate (27 vs. 35 vs. 39 mmol/L). Notably, the study used a fixed prescription of dialysate potassium on all occasions (2 mmol/L). They used polysulfone filters with a surface area of 1.6 m^2, the blood supply was 300 mL/min, and the dialysate supply was 500 mL/min. The total potassium removed was 116.4 ± 21.6 mmol with low dialysate bicarbonates (27 mmol/L), 73.2 ± 12.8 mmol with 35 mmol/L bicarbonates and 80.9 ± 15.4 mmol with 39 mmol/L bicarbonates. These small differences did not reach statistical significance (P = NS)[4] in accordance with the results of our study. This may be due to the small differences in dialysate bicarbonate levels between the 2 groups (it ranged from 30 to 33 mEq/L), but also to our small number of patients. No relationship was found between presession serum bicarbonate levels and potassium excretion in our patients in both dialysis modalities (conventional HD and predilution HDF).

Basile et al found a removal rate of 88.4 ± 23.2 mmol/session in a 4-hour conventional hemodialysis session.[14] This agrees with several reports of prior studies.[2,12,14,18] Blumberg et al studied potassium kinetics in 14 hemodialyzed patients (7 males and 7 females) by collecting the ultrafiltrate during the first session of the week. The filter surface area was 2 m^2, the dialysate potassium was 1 mmol/L, the bicarbonate was 40 mmol/L, and the glucose in 5 of them was 11 mmol/L. The blood pump was 300 mL/min, and the dialysate flow was 500 mL/min. The total potassium removed was 107.1 ± 6 mmol/session,[2] a result that has been confirmed by other studies.[12,19] The differences between our study and that of Blumberg et al were in the potassium found in the dialysate (which was higher in our study), the bicarbonates (lower in our study), and the blood pump (higher in our study). However, since the potassium gradient between the blood and dialysate has a dominant role in potassium loss, perhaps this explains why Blumberg et al found greater potassium loss in 1 session.[2]

Capdevila et al studied 35 hemodialyzed patients (on Monday or Tuesday, after the long 3-day interdialytic interval) using Polyflux (Polyamix) filters with a surface area of 1.6 and 2 m^2, a dialysate pump of 500 mL/min total and an average blood supply of 438 ± 12 and 437 ± 13 mL/min (with 37 mmol/L of acetate or 33 ± 4 mmol/L of bicarbonate, respectively), with 2 mmol/L of dialysate potassium (for all patients in both cases), collecting the ultrafiltrate in a tank for further analysis. They took the last blood sample 90 minutes after the end of the session, following roughly the same procedure as done in our study. Finally, potassium removal was equal using either method; the total potassium removed with dialysate bicarbonate was 295.9 ± 9.6 mmol/session, and with acetate, it was 299.0 ± 14.4 mmol/session.[3] The main difference between the present study and that of Capdevila et al is that the latter was performed after the 3-day interdialytic interval, where presumably, the potassium gradient between the blood and dialysate was greater. In addition, bicarbonates for all patients in our study were measured at ≤ 33 mEq/L, dialysate potassium equalled 2 or 3 mEq/L, the session duration ≥ 4 hours and the surface area of the filters was larger. Most important was that, in this study, the potassium measured was the sum of the potassium removed and the potassium in the dialysate (which was $500 \times 4 \times 60 \times 2 = 240$ mmol). This explains why this value was so large.[3] The same method was followed in another study, where they found a potassium removal of over 350 mEq in 1 conventional dialysis session.[1]

The small number of patients may be considered a limitation of this study. However, the results showed that consistently potassium excretion in predilution HDF was very high, except in one patient. A second limitation is that we determined urea and potassium levels 1 hour after the end of the session for better distribution of urea. Perhaps it would be better to determine the urea after 90 minutes (for even better redistribution). Of course, the potassium level1 hour after the end of the session is a little higher than the levels after the end of the session. Finally, 2 of our patients had a lower than desired URR due to their large body weight (and body surface area), who did not accept to increase their session duration further.

In conclusion, the present study shows that less potassium is removed through conventional hemodialysis than with predilution online HDF, and this removal is affected by dialysate potassium levels. In conventional hemodialysis, the use of β-blockers was associated with increased serum potassium levels before the dialysis as well as 1 hour after the completion of dialysis, and there was no difference between conventional hemodialysis and predilution online HDF in the amount of potassium removed. Dialysate bicarbonate levels were not related to the amount of potassium removed during sessions, either in conventional hemodialysis or predilution online HDF.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Scientific Counsil of General Hospital of Komotini University (Date: September 13, 2022, Number: 4/2022).

Informed Consent: Written informed consent was obtained from all patients who participated in this study.

Peer-review: Externally peer-reviewed.

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