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THE IMPACT OF EDUCATION ABOUT SPECIFIC COOKING METHODS ON SERUM POTASSIUM LEVELS IN PATIENTS ON HEMODIALYSIS

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Summary

Progression of chronic kidney disease often results with developing hyperkalemia; the increased serum level of potassium, which causes cardiac, neuromuscular and gastrointestinal complications. Hyperkalemia is generally associated with cardiac arhythmias and higher risk of mortality in patients on hemodialysis. The aim was to determine the impact of education on potassium control among patients on hemodialysis, while basing additional education on potassium-reducing techniques during food preparation and applying diet prepared accordingly to learned techniques. Participants were 47 patients on hemodialysis divided in control (n=22) and intervention (n=25) groups. All participants were educated by trained dietitian and received materials about proper nutrition at the beginning of the 1-year longitudinal study. The intervention group was educated additionally on potassium-reducing food preparation techniques. While both groups received two hospital meals per day during hemodialysis, meals for the intervention group were prepared accordingly to suggested food preparation techniques. Biochemical parameters were monitored during the study according to standard methods. The results showed that there was significant change in reduction of serum levels of potassium in intervention group compared to control group after one year of the study (p=0.037). Also, monthly serum levels of potassium were significantly reduced (p<0.05), compared to baseline of the study, during first 8 months in the control group and during all 12 months in the intervention group. Education about food preparation, proper diet alterations and its implementation can be useful in decreasing serum potassium levels and preventing hyperkalemia in patients on hemodialysis.

Keywords: hemodialysis, hyperkalemia, potassium, cooking methods

Introduction

Chronic kidney disease is characterized by imbalance of electrolyte levels, which can cause many health complications. One of the progression results of chronic kidney disease is hyperkalemia, or increased serum level of potassium, with high prevalence among dialysis patients (Einhorn et al., 2009; Kutlugun et al., 2017). It is estimated that there is approximatelly 50 mmol/kg of total body potassium, of which 2% is extracelullar, so the smallest changes in its serum level can cause homeostasis disorder (Putcha and Allon, 2007). Fluctuations in serum potassium level lead to serious health problems, such as neuromuscular (Kes, 2001; Montague et al., 2008) and gastrointestinal complications (Kes, 2001). Also, hyperkalemia is closely associated with cardiac arhythmias (Kes, 2001; Bleyer et al., 2006; Montague et al., 2008) and consequently higher risk of mortality in patients on hemodialysis (Noori et al., 2010; Pani et al., 2014; Yusuf et al., 2016). Reference range for an adequate serum potassium level is 3.9 - 5.1 mmol/L, while concentrations over the higher range value are considered increased (Flegar - Meštrić et al., 2000). This emphasizes the importance of potassium regulation, which depends on renal secretion, intracellular and extracellular distribution, and dietary intake (Brown, 1986). Dietary intake of potassium is the factor that can be controlled by dietitians and patients themselves and correlates with higher 5-year mortality (Noori et al., 2010).

Control over fluid and electrolyte levels in patients on hemodialysis is one of the main goals in maintaining patients health status. Recommendations for daily dietary intake of potassium for patients on hemodialysis are 1500 - 2700 mg (Fouque, 2003).

For managing disease, patients with chronic kidney disease require effort of medical stuff and education about adjusting their eating habits according to appropriate recommendations and hemodialysis treatments frequency (Jahanpeyma et al., 2017). Education of patients on hemodialysis is usually based on limitations, in this case on limiting foodstuffs naturally high in potassium or in which high concentration of potassium is a result of industrial process. Published studies proved that potassium content in food can be reduced by certain techniques during food preparation (Yaseen, 1993; Burrowes and Ramer, 2008; Bethke and Jansky, 2008; Cubadda et al., 2009). For example, it can be reduced by double boiling, (boiling, changing water and boiling food again) (Burrowes and Ramer, 2008). The potassium content in pasta can be

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decreased by boiling up to 32%-39% of the baseline value (Yaseen, 1993) or even up to 70% (Cubadda et al., 2009). In potatoes, reduction can be achieved by boiling thin potato slices instead of dices (Bethke and Jansky, 2008). Therefore, these cooking techniques could be applied while preparing meals for patients on hemodialysis with the presumption that it may result by reduction of serum potassium level.

The aim of this study was to determine the impact of education, potassium-reducing food preparation techniques and application of accordingly prepared diet on potassium control among patients on hemodialysis.

Materials and methods

Participants and education

The one-year study was conducted at General Hospital „Dr. Josip Benčević" in Slavonski brod during 2016. The study included 47 participants, of which 28 men and 19 women, aged 61 to 67 years. All participants were patients with chronic kidney disease who underwent hemodialysis treatment three times per week in time period from 3 to 9 years. Duration of hemodialysis was 4-5 hours and it was performed by using bicarbonate solution on high- and low-permeability polysulfonate dialyzers with standard flow rates of blood and dialysate. The dialysate contained 0.5 mmol/L magnesium, 2.0 mmol/L potassium and 1.25 - 1.50 mmol/L calcium.

Participants were randomly divided in two groups, control group (n=22) and intervention group (n=25). At the beginning of the study, all participants finished an educational program for hemodialysis patients, which lasted for three days and was held by trained dietitian. Participants got information about recommended nutrition for patients on hemodialysis and were advised about their serum potassium level control, primarily by avoiding foods naturally rich in potassium. Written educational materials with menu samples and recommendations on nutrition and potassium intake were provided for all participants.

In addition to standard education, intervention group received instructions for preparing and thermaly processing foods at home on its own by techniques which significantly reduce potassium food content. Additional education was held in one-on-one sessions with trained dietitian for 15-20 minutes. It was provided once per week during the first two months of the study and later on participants requests during the one-year period of the study.

Table 1. Example of a standard hospital menu for patients on hemodialysis and an optimized menu according to changes in nutritive content considering thermal processing

<table>
<tr><th></th><th>Menu – fresh ingredients</th><th>Menu – standard processing</th><th>Menu - optimized</th></tr>
<tr><td rowspan="6">Breakfast</td><td colspan="3">Bread, white (100 g)</td></tr>
<tr><td colspan="3">Fruit tea</td></tr>
<tr><td colspan="3">Honey (20 g)</td></tr>
<tr><td colspan="3">Butter (20 g)
Marmelade (20g)</td></tr>
<tr><td colspan="3">Cottage cheese (60g)</td></tr>
<tr><td colspan="3">Apple (100 g)</td></tr>
<tr><td rowspan="11">Lunch</td><td colspan="3">Vegetable soup (200 mL)</td></tr>
<tr><td>Fresh beef round (100 g)</td><td rowspan="3">Cooked beef round (100 g)</td><td rowspan="3">Stewed beef round (meat soaked in water 1 h before thermal processing) (100 g)</td></tr>
<tr><td>Sunflower oil (10 g)</td></tr>
<tr><td>Salt (1 g)</td></tr>
<tr><td>Fresh potato (200 g)</td><td rowspan="3">Steamed potatoes (160g)</td><td rowspan="3">Potatoes boiled in water (160 g) (potatoes soaked in water 1 h before thermal processing)</td></tr>
<tr><td>Olive oil (10 g)</td></tr>
<tr><td>Salt (1 g)</td></tr>
<tr><td>Fresh carrot (100 g)</td><td rowspan="3">Fresh carrot boiled in water (100 g)</td><td rowspan="3">Stewed fresh carrot (100 g)</td></tr>
<tr><td>Red onion (10 g) White onion (1 g)</td></tr>
<tr><td>Olive oil (5 g)
Salt (1 g)</td></tr>
<tr><td colspan="3">Orange (100g)</td></tr>
<tr><td rowspan="10">Dinner</td><td>Turkey fillet (60 g)</td><td rowspan="3">Roasted turkey fillet (60 g)</td><td rowspan="3">Stewed turkey fillet (meat soaked in water 1 h before thermal processing) (100 g)</td></tr>
<tr><td>Sunflower oil (10 g)</td></tr>
<tr><td>Salt (1g)</td></tr>
<tr><td>Rice (60 g)</td><td rowspan="3">Cooked rice (60 g)</td><td rowspan="3">Cooked rice (60g)</td></tr>
<tr><td>Red onion (10 g)</td></tr>
<tr><td>Sunflower oil (10 g), Salt (1g)</td></tr>
<tr><td>Freezed broccoli (100 g)</td><td rowspan="3">Frozen broccoli boiled in water (100 g)</td><td rowspan="3">Stewed frozen broccoli (100 g)</td></tr>
<tr><td>Oil (10 g)</td></tr>
<tr><td>Salt (1g)</td></tr>
<tr><td colspan="3">Yogurt with probiotics (100 g)</td></tr>
</table>

Table 1. Cont.

	Nutritional value of fresh foodstuffs from standard nutritional tables	Nutritional values based on standard thermal processing	Nutritional values based on optimized thermal processing
Energy (kcal)	1832	1826	1828
Protein (g)	66.9	65.3	65.8
Change in protein content during thermal processing of foodstuffs (%)	/	-2.4	-1.64
Potassium (mg)	3012	2635	2068
Change in potassium content during thermal processing of foodstuffs (%)	/	-12.5	-31.3

Participants in both groups received two hospital meals per day during hemodialysis. The control group received meals prepared by following standard recommendations for hemodialysis patients, while the intervention group received meals prepared accordingly to suggested techniques for lowering potassium food concentration.

Computer software (Prehrana, Infosistem d.d., Zagreb, Croatia) was used for designing standard hospital menu for patients on hemodialysis and optimized menu, with adjusted cooking methods for increasing potassium loses during foodstuff preparation. All standard menus were generated according to standard processing methods and optimized menus according to potassium-reducing techniques during food preparation (example Table 1). Literature references were used to modify food composition while designing menus and calculating food potassium loses: concentration of potassium in peas could be reduced 44% and in beans 60% (Rickman et al., 2007) by boiling; boiling diced potatoes could reduce its potassium content by 50% (Bethke and Jansky, 2008), while steaming potatoes reduces it by 10% (Vrdoljak, 2010).

The study was conducted in accordance with the principles of the Declaration of Helsinki, and the study protocol was approved by the ethics committee. All participants signed a written informed consent before the start of the study.

Biochemical methods

Blood samples from each participant were collected at the baseline of the study and once a month during the one-year period of the study. Analysis of the samples were carried out at the Biochemical laboratory of the General Hospital „Dr. Josip Benčević" in Slavonski Brod. Standard biochemical method for assessing blood levels of potassium was used (Flegar-Meštrić et al., 2000).

Statistical analysis

Descriptive statistical methods were used in describing data. Normally distributed variables were expressed as average values and standard deviations, while not normally distributed ones were expressed as median (interquantile range). Intergroup differences were estimated by using the χ^2 test and Fischer's exact test. Intragroup differences were estimated by using Friedman's or Wilcoxon test. For data analysis *Excel 2013* (Microsoft, Seattle, WA, USA) and *SPSS* statistical package (version 17.0, SPSS Inc., Chicago, IL, USA) were used. Differences were considered significant when p<0.05.

Results and discussion

There were 47 participants included in this study, of which 28 (59.6%) men and 21 (44.7%) women. Participants were randomly divided in control group (n=22; 46.8%) and intervention group (n=25; 53.2%). There was no significant difference in age between these two groups (p=0.084) (Table 2). The most participants (44.7%) were aged 65-75 years.

Median of duration of hemodialysis for all participants was 5 years, without significant difference (p=0.441) between control and intervention groups (Table 2).

During one year period, standard menus were applied on the control group and optimised menus on the intervention group. Considering thermal processing of foodstuffs in both menues, it was showed that potassium content in the standard menu could be reduced by 12.5% and by 31% in the optimized menu (example Table 1). Also, it was showed that potassium concentration in food prepared for patients on hemodialysis can be decreased with minimum food protein changes (example Table 1). Preserving the protein intake is an important factor in nutrition of hemodialysis patients, since studies proved connection between low protein intake and increased risk of mortalily in this population (Shinaberger et al., 2006). Also, the ability to incorporate foodstuffs, which patients on hemodialysis usually avoid, brings variety and enriches their diet.

Table 2. Characteristics of participants according to groups, age and duration of hemodialysis

	Median (interquantile range)			p*
	Control group (n=22)	Intervention group (n=25)	All participants	
Age (years)	68 (60 – 73)	73 (62 – 77)	69 (61 – 76)	0.084
Duration of hemodialysis (years)	4 (2.5 – 8)	5 (3 – 10)	5 (3 – 9)	0.441

*Mann Whitney test

At the baseline of the study, there was no significant difference observed in serum potassium levels between control (5.9 mmol/L [5.4 - 6.5]) and intervention (6.2 mmol/L [5.6 - 6.7]) groups, but significant intergroup differences were found at 1, 3, 4, 10 and 11 months ($p<0.05$), where serum potassium levels in the intervention group were lower than in the control group (Table 3). During the one-year period, serum potassium levels decreased in both groups; mean reduction of serum potassium levels was -0.3 mmol/L [-0.8 do 0] in the control group and -0.7 mmol/L [-1.1 do -0.2] in the intervention group. The average change in serum potassium levels between groups was significant ($p=0.037$). Taking into consideration the reference range for serum potassium level, median of monthly values for both groups were showing that patients were in chronic hyperkalemia, except for months 3, 4 and 5 for patients in the intervention group. Despite of decrease, the control group stayed in chronic hyperkalemia with median values of serum potassium levels do not descending below 5.2 mmol/L (Table 3). Another study (Kovesdy et al., 2007) also showed frequency of hyperkalemia among hemodialysis patients. Three-year cohort study conducted on 81,013 hemodialysis patients associated serum potassium levels between 4.6-5.3 mmol/L with greatest survival among patients on hemodialysis, while increased mortality was associated with serum potassium levels <4.0 and ≥5.3 mmol/L. The same study conducted additional biochemical measurments on 74,219 patients on hemodialysis, which showed that 12.5% of them had an average serum potassium level 5.5 mmol/L or higher measured during three months (Kovesdy et al., 2007).

Table 3. Average serum potassium levels at the baseline and during the study compared between grups

Potassium*	Median (interquantile range)			p**
	Control group (n=22)	Intervention group (n=25)	All participants	
Baseline	5.9 (5.4 - 6.5)	6.2 (5.6 - 6.7)	6.1 (5.4 - 6.6)	0.529
Month 1	5.7 (5.3 - 6.2)	5.2 (4.6 - 5.5)	5.4 (4.8 - 5.8)	**0.005**
Month 2	5.5 (5.1 - 5.8)	5.2 (4.8 - 5.7)	5.3 (4.9 - 5.7)	0.253
Month 3	5.5 (4.9 - 5.9)	5.0 (4.7 - 5.3)	5.2 (4.7 - 5.7)	**0.041**
Month 4	5.6 (5.0 - 5.8)	5.0 (4.6 - 5.7)	5.3 (4.9 - 5.7)	**0.049**
Month 5	5.4 (5.0 - 5.8)	5.0 (4.7 - 5.8)	5.3 (4.8 - 5.8)	0.109
Month 6	5.4 (5.0 - 5.9)	5.3 (4.7 - 5.9)	5.4 (4.8 - 5.9)	0.509
Month 7	5.2 (4.9 - 5.9)	5.5 (5.0 - 5.9)	5.3 (4.9 - 5.8)	0.369
Month 8	5.4 (5.0 - 6.1)	5.5 (4.9 - 5.8)	5.4 (5.0 - 5.9)	0.991
Month 9	5.8 (5.4 - 6.4)	5.8 (5.2 - 6.4)	5.8 (5.3 - 6.4)	0.593
Month 10	6.0 (5.5 - 6.6)	5.5 (5.0 - 5.9)	5.7 (5.2 - 6.2)	**0.018**
Month 11	6.0 (5.5 - 6.4)	5.4 (4.8 - 6.1)	5.8 (5.3 - 6.3)	**0.044**
Month 12	5.8 (5.3 - 6.4)	5.5 (5.0 - 6.1)	5.6 (5.1 - 6.1)	0.138

*reference range is 3.9-5.1 mmol/L for both men and women
**Mann Whitney test (significance at $p<0.05$); significant results are bolded

Monthly serum levels of potassium for control and intervention groups were compared with data from the baseline of the study, provided in Table 3. Data analysis showed that serum potassium levels were significantly reduced (p<0.05) in the control group in the first 8 months and in all 12 months of the study in the intervention group (Table 4). Nutritional education had the impact on decreasing dietary potassium intake in both groups. Greater changes in potassium intake were seen from results of the intervention group compared to the control, that can be explained by providing additional education on potassium-reducing techniques during food preparation.

Table 4. Significance (p-values) between the baseline and serum potassium levels during the study

PB* vs. month	p**	
	Control group (n=22)	Intervention group (n=25)
PB vs. month 1	**0.044**	**<0.001**
PB vs. month 2	**0.002**	**<0.001**
PB vs. month 3	**0.001**	**<0.001**
PB vs. month 4	**0.003**	**<0.001**
PB vs. month 5	**0.012**	**<0.001**
PB vs. month 6	**<0.001**	**<0.001**
PB vs. month 7	**<0.001**	**0.002**
PB vs. month 8	**0.023**	**0.002**
PB vs. month 9	0.455	**0.013**
PB vs. month 10	0.897	**<0.001**
PB vs. month 11	0.638	**0.008**
PB vs. month 12	0.432	**0.002**

*PB - potassium baseline

**Wilcoxon test (significance at p<0.05); significant results are bolded

Study conducted on 23 patients on hemodialysis showed that six-month implementation program has positive impact on changing dietary habits, resulting with significant decrease in phosphorous, potassium and sodium intake and improving nutritional status of patients (Yang et al., 2003). Another study conducted on 30 hemodialysis patients also showed positive results after short education, resulting with signifficant serum potassium level decrease (Jahanpeyma et al., 2017). Also, study showed that education on food preparation methods resulted in decreasing serum phosphate levels in patients on hemodialysis (Vrdoljak et al., 2017).

Despite the fact that dialytic therapies make the foundation in treating hemodialysis patients, dietary strategies must not be ignored because recommended and individually adjusted nutrition can help to mantain chronic kidney disease and avoid hyperkalemia (Kovesdy et al., 2007; Pani et al., 2014).

Despite given instructions for potassium reducing techniques in food preparation at home, one of the limitations of this study was the inability to monitor adherence of its use. Although participants confirmed adherence during consultations with dietitian and monthly blood control showed reduction in potassium levels in the intervention group, its hard to distinguish to what extent preparation at home contributed to its reduction. Therefore, further studies could be focused on exploring this limitation.

Conclusions

Patients with chronic kidney disease are specific population with demanding dietary recommendations. Hyperkalemia is a common disorder in patients on hemodialysis, which can be influenced by proper diet. Additional education about specific cooking methods proved beneficial for hemodialysis population, as the change of serum potassium levels in the intervention group was significant. Moreover, the role of trained dietitian mantaining patients with chronic kidney disease in hospitals should be unquestionable. Education about food preparation, proper diet alterations and its implementation can be useful in decreasing serum potassium levels and preventing hyperkalemia in patients on hemodialysis.

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