Effect of personalized nutritional counseling in maintenance hemodialysis patients

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Abstract
Monitoring nutritional parameters is an integral part of hemodialysis (HD) patient treatment program. The purpose of this study was to evaluate the impact of the personalized nutritional counseling (PNC) on calcium–phosphorus metabolism, potassium, albumin, protein intake, interdialytic weight gain (IDWG), body composition parameters and fluid overload in HD patients. This was a multicenter longitudinal intervention study with 6 months of follow-up and 731 patients on maintenance HD from 34 dialysis units in Portugal were enrolled. Biochemical and body composition parameters were measured at baseline, 1, 3 and 6 months after the PNC. Patient's mean age was 64.9 (95% confidence interval [CI]: 63.8–66.0) years and mean HD time was 59.8 (95% CI: 55.3–64.3) months. Regarding data comparison collected before PNC vs. 6 months after, we obtained, respectively, the following results: patients with normalized protein catabolic rate (nPCR) ≥ 1 g/kg/day = 66.5% vs. 73.5% (P = 0.002); potassium > 5.5 mEq/L = 52% vs. 35.8% (P < 0.001); phosphorus between 3.5 and 5.5 mg/dL = 43.2% vs. 52.5% (P < 0.001); calcium/phosphorus (Ca/P) ratio ≤ 50 mg/dL = 73.2% vs. 81.4% (P < 0.001); albumin ≥ 4.0 g/dL = 54.8% vs. 55% (P = 0.808); presence of relative overhydration = 22.4% vs. 25% (P = 0.283); IDWG > 4.5% = 22.3% vs. 18.2% (P = 0.068). PNC resulted in a significant decrease in the prevalence of hyperkalemia, hypophosphatemia and also showed amelioration in Ca/P ratio, nPCR and an increase in P of hypophosphatemic patients. Our study suggests that dietetic intervention contributes to the improvement of important nutritional parameters in patients receiving hemodialysis treatment.

Key words: Nutrition, patient education, outcomes research

INTRODUCTION
Patients in maintenance hemodialysis (HD) require proper, intensive and sufficient instruction, as well as repeated reinforcement to deal with the complex renal diet. The main goals of nutritional counseling should be helping patients manage their own diet in the correct way and help them feel in control.1 Because of the increased
nutrient requirements and dietary restrictions, management of anthropometric and biochemical parameters, such as phosphorus, calcium, potassium, albumin and normalized protein catabolic rate (nPCR), in HD patients must be taken into account, therefore patients should follow a diet to improve or maintain nutritional status. With the decline of the renal function, the intake of phosphorus, potassium, protein and fluids must be controlled. A high potassium intake is related with an increased death risk in these patients because it can lead to cardiac arrest. Similarly, hyperphosphatemia is associated with mineral bone disorder and increases cardiovascular mortality risk in HD patients. Furthermore, the presence of hypophosphatemia has been linked to muscle weakness, ventilatory failure, myocardial dysfunction and other complications. Moreover, recurrent fluid overload leads to increased cardiac strain causing left ventricular hypertrophy and ultimately dilatation, which leads to higher cardiac mortality in these patients.

HD patients are characterized by catabolic processes that modify their body composition, such as inflammation, muscle wasting and declined visceral protein stores. It is well recognized that a low protein intake can predispose these patients to protein energy wasting, and losses of amino acids during HD might also contribute. Bioimpedance spectroscopy (BIS) seems to be a valid method for assessing and monitoring hydration and nutritional status in HD patients, and has been shown to be as precise as the gold standard reference methods and considered as being of high reproducibility and specificity. Apart from determining the individual fluid status—total body water, intra and extracellular water (ECW)—independently, it analyzes body composition (body cell mass, lean mass and fat mass) simply, objectively and noninvasively. ECW is the compartment that predominantly reflects overhydration (OH).

Nutritionists and dietitians are considered important parts of the dialysis team, providing nutritional counseling and following the effects of dietetic recommendations on nutritional status and medical conditions of dialysis patients. Dietary advice in HD patients is recommended by the European Best Practice Guidelines on Nutrition as well as by the Kidney Disease Outcomes Quality Initiative, through a nutritional care plan and individualized dietary counseling, which promotes an accurate selection of food options.

The aim of this study was to prospectively evaluate the effects of personalized nutritional counseling (PNC) in laboratory parameters and body composition of HD patients during 6 months of follow-up.

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**MATERIALS AND METHODS**

**Study design**

This was a multicenter longitudinal intervention study of a cohort of maintenance HD patients with 6 months of follow-up.

**Patients**

This study was performed at 34 Nephrocare dialysis units in Portugal. Between July 2013 and May 2014, 731 patients were assigned to receive PNC depending on their biochemical and nutritional parameters. At baseline, an individualized consultation by a renal dietitian was provided to all participants with the aim of improving patient’s altered parameters: Phosphorus >5.5 mg/dL or <3.5 mg/dL, potassium >5.5 mEq/L, interdialytic weight gain (IDWG) >4.5%, relative OH/ECW ≥15% and/or nPCR < 1 g/kg/day. The consultation consisted of a 30- to 40-minute PNC session through motivational advice focused on the altered parameters. A 24-hour recall was also performed and discussed with patients in order to recommend eating habits changes and to empower them to get involved in their health care. A laboratory results review with the patients was also performed. A book containing information about fluid intake, potassium, phosphorus, protein, sodium and additives management, and 16 recipes was given to each patient. Whenever considered necessary, written summarized advice with specific food alternatives was also provided at the end of the session, and verbal counseling was reinforced. Depending on the patient shift, patient’s caregivers were invited to be present in the consultation, which took place before or after the HD treatment.

Inclusion criteria included age ≥18 years and three times weekly in-center HD for ≥3 months (with an online hemodiafiltration technique). All patients were dialyzed with high-flux (Helixone®, Fresenius Medical Care Deutschland GmbH, Germany) membranes and ultrapure water in accordance with the criteria of ISO regulation 13959:2009—water for HD and related therapies.

**Data analysis**

Dry weight (DW), IDWG %, body mass index (BMI), lean tissue index (LTI), fat tissue index (FTI), potassium, phosphorus, calcium/phosphorus (Ca/P) ratio and nPCR, were recorded at baseline, 1, 3 and 6 months after the PNC. Serum albumin was measured both at baseline and at the end of the study. Anthropometric and biochemical data
were registered before the midweek dialysis session, close to the day in which the BIS was carried out.

Analysis of body composition

In all patients, BIS was carried out using the Body Composition Monitor (Fresenius Medical Care Deutschland GmbH, Germany), which takes measurements at 50 frequencies in a range of 5–1000 kHz. The measurement was performed approximately 30 minutes before the midweek HD session, with four conventional electrodes being placed in the patient, who was lying in the supine position: two electrodes on the hand and two electrodes on the foot contralateral to the vascular access. Regarding the quality of measurements, all exceeded 95%. LTI (kg/m²), FTI (kg/m²) and OH/ECW were obtained directly through BIS. One of the limitations documented by the manufacturer of the Body Composition Monitor consists of its use in patients with major amputations of limbs or with pacemakers, as it does not guarantee that the measurements will be accurate in these patients. Therefore, these patients were excluded from the study.

Statistical analysis

All statistical tests were performed using the Statistical Package for the Social Sciences (SPSS) 14.0 software (SPSS, Inc., Chicago, IL, USA). Categorical variables were described as percentage of relative frequencies and quantitative variables as mean (95% confidence interval [CI]).

Differences between clinical data before and after PNC were assessed by Student’s t-test for paired samples, Cochran’s Q and Friedman’s test. A P value of <0.05 was considered to be statistically significant.

RESULTS

This study included 731 patients of which, 53 (7.3%) died, 9 (1.2%) were transplanted and 9 (1.2%) transferred to other dialysis units during the study period. From the remaining 660 patients, 43.8% were women and 34.4% had diabetes, the mean age was 64.9 (95% CI: 63.8–66.0) years and mean HD time was 59.8 (95% CI: 55.3–64.3) months.

Patient’s baseline parameters are summarized in Table 1 as mean (95% CI). Of the total sample, 5.5% were underweight (BMI < 18.5 kg/m²), 44.2% had a BMI between 18.5 and 24.9 kg/m², the prevalence of overweighted patients was 28.6% (BMI 25.0–29.9 kg/m²) and 21.7% were obese (BMI > 30.0 kg/m²).

The frequency of distribution of categorized parameters over time among patients enrolled is shown in Table 2. At

Table 1 Baseline characteristics of HD patients participating in the study (mean [95% CI])

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Baseline n = 660</th>
</tr>
</thead>
<tbody>
<tr>
<td>DW (kg)</td>
<td>68.83 (67.6–70.1)</td>
</tr>
<tr>
<td>nPCR (g/kg/day)</td>
<td>1.13 (1.1–1.2)</td>
</tr>
<tr>
<td>Albumin (g/dL)</td>
<td>3.93 (3.9–4.0)</td>
</tr>
<tr>
<td>K (mEq/L)</td>
<td>5.54 (5.5–5.6)</td>
</tr>
<tr>
<td>P (mg/dL)</td>
<td>4.51 (4.4–4.6)</td>
</tr>
<tr>
<td>Ca/P (mg/dL)</td>
<td>40.05 (38.8–41.3)</td>
</tr>
<tr>
<td>IDWG (%)</td>
<td>3.50 (3.4–3.6)</td>
</tr>
<tr>
<td>OH/ECW (%)</td>
<td>8.97 (8.3–9.6)</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>25.86 (25.4–26.3)</td>
</tr>
<tr>
<td>FTI (kg/m²)</td>
<td>13.31 (12.8–13.8)</td>
</tr>
<tr>
<td>LTI (kg/m²)</td>
<td>12.6 (12.3–12.8)</td>
</tr>
</tbody>
</table>

BMI = body mass index; Ca/P = calcium/phosphorus ratio; CI = confidence interval; DW = dry weight; FTI = fat tissue index; IDWG = interdialytic weight gain; K = potassium; LTI = lean tissue index; nPCR = normalized protein catabolic rate; OH/ECW = relative overhydration/extracellular water; P = phosphorus.

the end of the study all the parameters analyzed improved, with the exception of hypophosphatemia and OH. However, if we consider the effect of the PNC on the altered parameters, on which it was focused on, a significant positive impact in all the data studied was observed (Table 3).

DISCUSSION

Our findings suggest that PNC led to better outcomes that support the relevance of this type of approach in avoiding inappropriate food intake and improving nutritional markers.

Although serum potassium levels at baseline were above the desirable target, the nutritional intervention demonstrated a significant and continuous decrease in the number of patients with hyperkalemia from 52.0% to 35.8% (Table 2) while potassium mean within patients with hyperkalemia had a reduction of 0.67 mEq/L (P < 0.001) (Table 3). Changes in serum potassium are frequent in HD patients and it may vary throughout the day depending on food choices. Noori et al. state that potassium levels in these patients are influenced by dietary potassium intake, but they suggest that this occurs only when the intake of potassium is too high or too low. Moreover, these values are also affected by other factors such as dialysis dose, schedule of HD treatments and the degree of residual renal function. In the same study, the authors found an association between the high intake of potassium and the increased risk of death in patients on HD, which reinforces the importance of limiting the daily intake of potassium.
In other studies, different laboratory values such as phosphorus, calcium, Ca/P ratio and also knowledge about dietary phosphorus management in patients with serum phosphorus level >6.0 mg/dL, were measured before and after intervention. Significant improvements were found after 6 months of intervention.1,22 These results are in line with those shown in our study as we found a significant decrease in the prevalence of hyperphosphatemia as well as in the number of patients with Ca/P > 50 mg/dL with a reduction of 1.32 mg/dL (P < 0.001) and 11.07 mg/dL (P < 0.001), respectively (Table 3).

Regarding hypophosphatemia in all the participants, improvement was achieved during the first 3 months, but after that period the number of cases rose (Table 2). Despite this situation, after the intervention a slight enhancement from 2.5 to 3.11 mg/dL (P < 0.001) was observed in serum phosphorus of the hypophosphatemic patients, showing a positive effect of the PNC. However, the positive results achieved regarding the percentage of patients with phosphorus within the target values (3.5–5.5 mg/dL), might have been due to the correction of hyperphosphatemia (Table 2).

It is important to highlight the high prevalence of hypophosphatemia seen among our study population, actually higher than hyperphosphatemia. A low phosphorus value is a simple marker of protein-energy wasting and is a risk factor for the presence of comorbidities, including inflammation,23 although special attention must be paid in these cases and specific dietetic recommendations must be given in order to improve nutritional status.

Our data show that PNC was also effective in gradually reducing the number of patients with low protein intake (nPCR < 1 g/kg/day; P = 0.002) by improving mean nPCR value after the first month of the intervention, which remained similar until the end of the follow-up period

### Table 2
Changes in different parameters at baseline and during follow-up (%)

| nPCR ≥ 1 g/kg/day | Month 0 | Month 1 | Month 3 | Month 6 | P  
|------------------|---------|---------|---------|---------|-----
| 66.5             | 71.6    | 71.7    | 73.5    | 0.01    |
| Albumin ≥ 4.0 g/dL | 54.8    | —       | —       | 55.0    | 0.81|
| K > 5.5 mEq/L    | 52.0    | 43.8    | 39.8    | 35.8    | <0.001|
| Phosphorus (mg/dL)|         |         |         |         |
| <3,5             | 28.5    | 28.2    | 28.1    | 28.9    | <0.001|
| 3.5-5,5          | 43.2    | 49.6    | 55.4    | 52.5    |     |
| >5,5             | 28.3    | 22.1    | 16.6    | 18.6    |     |
| Ca/P ≤ 50 mg/dL | 73.2    | 79.2    | 84.3    | 81.4    | <0.001|
| IDWG > 4.5%      | 22.3    | 21.1    | 23.2    | 18.2    | 0.07 |
| OH/ECW ≥ 15%     | 22.4    | 23.2    | 24.8    | 25.0    | 0.28 |
| Normal FTI (kg/m²) | 67.7    | 69.0    | 66.9    | 67.9    | 0.01 |
| Normal LTI (kg/m²) | 54.3    | 54.7    | 53.2    | 50.8    | 0.01 |

Ca/P = calcium/phosphorus ratio; FTI = fat tissue index; IDWG = interdialytic weight gain; K = potassium; LTI = lean tissue index; nPCR = normalized protein catabolic rate; OH/ECW = relative overhydration/extracellular water; P = phosphorus.

### Table 3
Evolution of different measures during the study period in patients with altered parameters before the personalized nutritional counseling (mean [95% CI])

| nPCR ≥ 1 g/kg/day | n | Month 0 | Month 1 | Month 3 | Month 6 | P  
|------------------|---|---------|---------|---------|---------|-----
| 301              | 3.61 (3.5–3.6) | —       | —       | 3.75 (3.7–3.8) | <0.001|
| Albumin < 4.0 g/dL | 188 | 2.50 (2.4–2.6) | 3.09 (2.9–3.2) | 3.15 (3.0–3.3) | 3.11 (3.0–3.3) | <0.001|
| P < 3.5 mg/dL    | 187 | 6.70 (6.6–6.8) | 5.77 (5.6–6.0) | 5.38 (5.2–5.6) | 5.38 (5.2–5.6) | <0.001|
| P > 5.5 mg/dL    | 343 | 6.28 (6.2–6.3) | 5.86 (5.8–5.9) | 5.70 (5.6–5.8) | 5.61 (5.5–5.7) | <0.001|
| Ca/P > 50 mg/dL | 177 | 61.18 (59.9–62.5) | 62.15 (54.2) | 49.02 (47.1–51.0) | 50.11 (48.1–52.2) | <0.001|
| IDWG > 4.5%      | 149 | 5.90 (5.7–6.2) | 5.30 (5.0–5.6) | 5.0 (4.8–5.4) | 4.70 (4.4–5.0) | <0.001|
| OH/ECW > 15%     | 134 | 20.05 (19.2–20.9) | 17.85 (16.8–18.9) | 15.80 (14.3–17.3) | 15.11 (13.7–16.6) | <0.001|
| nPCR < 1 g/kg/day | 208 | 0.84 (0.8–0.9) | 0.96 (0.9–1.0) | 0.95 (0.9–1.0) | 0.9 (0.9–1.0) | <0.001|

Abbreviations: Ca/P = calcium/phosphorus ratio; CI = confidence interval; IDWG = interdialytic weight gain; K = potassium; nPCR = normalized protein catabolic rate; OH/ECW = relative overhydration/extracellular water; P = phosphorus.
Increased morbi-mortality.

These patients should keep close to normohydration throughout the interdialytic interval controlling the fluid intake between dialysis sessions. Both fluid overload and higher IDWG % are associated with higher morbidity, poor survival and increased cardiovascular death in HD patients. Although not significant, the prevalence of high IDWG (>4.5%) among patients enrolled in this study decreased in the last month of the study in comparison with baseline. Moreover, the IDWG of patients with IDWG > 4.5% decreased significantly during the follow-up, from 5.9% to 4.7% (P < 0.001) (Table 3).

Clinical practice guidelines in chronic kidney disease commonly recommends that patients in maintenance HD must be regularly monitored and should have a dietary interview with a renal dietitian every 3–6 months. Our results also emphasize this necessity as we observed a light decline in some parameters, such as hypophosphatemia and Ca/P ratio (Table 3) on the sixth month after PNC and the best results for these parameters were achieved on the third month, suggesting that it could be of interest to reinforce nutritional advisory at this time. However, when comparing with baseline data, all of the laboratory parameters, with the exception of hypophosphatemia, improved significantly at the end of the study.

It has already been demonstrated that studies integrating self-management tools into the educational material and providing individualized counseling by a renal dietitian are those with large effect size. Dietary compliance is critical in the treatment of HD patients and, consequently, educating patients must be one of the major concerns of renal dietitians. There are some limitations to this study. First, this study was designed as an intervention study, but there was no control group. Finally, in the data collection, there was little account for the effect of comorbid illness, including markers of inflammation, on changes in dietary intake and nutritional status.

In summary, the results obtained in the present study show that individualized nutritional counseling is effective in improving parameters that have been associated with nutritional status and adverse outcomes in patients with end-stage renal disease. Nutritionists and dietitians through nutritional counseling and with the support of educational material, created specifically for these patients, can increase patient’s knowledge about diet and empower them with new skills and encouragement to have more appropriate food choices.

Dietetic professionals can promote behavioral changes and maintain long-term adherence to recommended dietary regimens and optimal nutrition prescription that can contribute to reduce cardiovascular risk factors and prevent malnutrition.
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