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Improving diet recipe and cooking methods attenuates hyperphosphatemia in patients undergoing peritoneal dialysis

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Abstract *Background and aims:* Hyperphosphatemia is an independent predictor for cardiovascular and all-cause mortality in patients undergoing peritoneal dialysis (PD). The study aimed to investigate the effect of dietary intervention on reducing serum phosphate concentration in hyperphosphatemic PD patients.
Methods and results: In this single-center clinical trial, 97 prevalent PD patients with serum phosphate concentration ≥1.6 mmol/l were allocated to the intervention ($n = 48$) or control ($n = 49$) group and followed up for 1 year. In addition to phosphate binder (calcium carbonate) therapy, patients in the intervention group were intensively educated to reduce phosphate-rich food intake and improve cooking methods. While stable in the control group (1.97 ± 0.20 to 1.94 ± 0.35 mmol/l, $p > 0.05$), the serum phosphate concentration decreased significantly in the intervention group (1.98 ± 0.28 to 1.65 ± 0.33 mmol/l, $p = 0.015$) concurrently with the drop in dietary phosphate intake (13.03 ± 3.39 to 10.82 ± 3.00 mg/kg ideal body weight/day, $p = 0.001$). Moreover, after 6 months of intervention, fewer patients needed to use calcium carbonate (from 64.6% to 41.5%, $p = 0.029$) and the medicine dose reduced significantly (from 2.25 (0, 3.94) to 0 (0, 1.50) g/day, $p < 0.001$).
Conclusions: Our data indicated that intensive dietary intervention of reducing phosphate-rich food intake and improving cooking methods attenuated hyperphosphatemia in PD patients. It suggests that regular assessment of dietary phosphate intake and modification of diet recipe and cooking methods are essential for hyperphosphatemia treatment in PD patients in addition to phosphate binder therapy.

Introduction

Hyperphosphatemia is highly prevalent in patients with end-stage kidney disease. Impaired renal phosphate clearance results in phosphate accumulation in the serum, which cannot be corrected by dialysis alone. Hence, >50% of patients undergoing hemodialysis (HD) or peritoneal dialysis (PD) show elevated serum phosphate concentrations above the level recommended in the current guidelines [1,2]. Hyperphosphatemia is an independent predictor for cardiovascular and all-cause mortality in patients undergoing dialysis, because it contributes to vascular calcification, ventricular hypertrophy, additional mineral dysmetabolism, etc. [3,4].

A cocktail regimen comprising adequate dialysis, phosphate-binding agents, and dietary phosphate restriction is recommended for hyperphosphatemia treatment in PD patients [5]. However, the efficacy of PD in clearing

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phosphate is limited to dialysis cycles [6], whereas phosphate binders show a different secondary effect [7]. In this case, dietary phosphate intake shall be mandatorily monitored in these patients.

Studies from our group and others indicated that hyperphosphatemic PD patients ingest higher phosphate than those with normal serum phosphate concentration [8,9]. The high phosphate intake is mainly attributed to high protein ingestion [8], which is recommended in PD patients to compensate protein loss in the dialysate [10]. Moreover, inorganic phosphate from phosphate-salt containing additives, soft drink, fast and processed food, etc. increases the overall phosphate intake significantly [11,12]. In addition, the final phosphate content in foodstuffs could be altered by different dermal processing methods [13]. Some cooking strategies such as boiling and soaking food in water before cooking could leach phosphate inside the food from the processing medium [14].

Dietary phosphate restriction is beneficial for hyperphosphatemia treatment in HD patients [15–17]. However, limited studies have conducted systemic dietary phosphate intervention in PD patients. Thus, the present study aimed to investigate whether intensive dietary intervention by modifying diet recipe and cooking methods could reduce serum phosphate concentration in hyperphosphatemic PD patients.

Methods

The study was a prospective, interventional trial, which was approved by the Ethical Committee of Ren Ji Hospital, Shanghai Jiao Tong University School of Medicine, China, and registered at ClinicalTrials.gov (ClinicalTrials.gov identifier: NCT01329497). Patients were recruited after providing informed consent.

Study population

PD patients with vintage longer than 3 months and serum phosphate level $\geq$1.6 mmol/l (lab reference range, 0.94–1.60 mmol/l) met the selection criteria. The exclusion criteria included malnutrition (according to subjective global assessment of nutrition, SGA), infection or inflammation (high-sensitive C-reactive protein (hs-CRP) $\geq$8 mg/l), and concurrent wasting disease, such as cancer or tuberculosis. Patients who were not able to write the 3-day diet diary because of poor education background, lack of time or family support, etc. were also excluded.

Our hospital has two PD centers that are located in different districts of Shanghai. Patients are admitted to the respective center according to their home location. There are no differences in clinical practice applied in the two centers, and patients are under the care of the same team of nephrologists and nurses. In the current clinical trial, to exclude between-group interaction, we recruited and allocated patients from one PD center to the intervention group and from the other center to the control group. All patients were followed up as outpatients monthly for 1 year.

Phosphate binder (calcium carbonate) therapy was prescribed to all patients after recruitment and stopped when serum phosphate concentration was lower than 1.6 mmol/l, or when severe side effects occurred (constant hypocalcemia, gastrointestinal intolerance, etc.). In addition to calcium carbonate, patients in the intervention group received additional dietary intervention, which will be elaborated in the following text.

Conditions required for withdrawal from the study included patient's own willingness to withdraw, severe malnutrition, kidney transplantation, transference to HD, or other serious medical conditions.

Dietary intervention and assessment

Patients in the intervention group were educated by a dietitian and a PD nurse every month on how to lower dietary phosphate intake. They were asked to reduce the ingestion of phosphate-rich food, especially food with a high phosphate to protein ratio (soft drink, processed or fast food, phosphate-salt additives, etc.), and food with high intestinal phosphate absorption rate (meat, dairy product, etc.) [11]. Food with low phosphate to protein ratio, such as egg white, fresh milk, etc., was recommended [11].

Moreover, patients were instructed to cook by boiling or stewing rather than by the traditional Chinese method of frying. These thermal processing methods are effective in reducing the phosphate content in foodstuffs without affecting their protein content [13,18]. For meat food, including fresh or processed pork, beef, lamb, poultry, aquatic products, etc., patients were advised to soak them in water for 1 h prior to cooking [13].

Patients were instructed to write a 3-day diet diary twice every month. They were trained to record the weight of raw food components of self-made food or beverages. They were also asked to record how the food was cooked. For processed food such as canned food, processed snacks, sauce or bottled beverages, etc., the patients were required to provide the nutritional composition label in addition to the weight. The 3-day diet diaries were reviewed and commented upon by the same dietitian every month. Patients then received individual advice on how to modify the diet recipe and cooking methods.

The efficiency of dietary intervention was evaluated by calculating the intake of dietary nutrients based on the 3-day diet diary. The dietary intake of phosphate, protein, calcium, potassium, sodium, and energy was estimated by using a food composition computer program (Keto Acids Diet Calculator 2.0; Fresenius–Kabi Co., Ltd, Beijing, China) [19]. The total energy intake (TEI) from the diet and peritoneal glucose absorption [20] was calculated. All the indices were normalized to ideal body weight (IBW) calculated as (height (cm) − 105) according to the Kidney Disease Outcomes Quality Initiative (K/DOQI) guidelines [10].

Clinical parameters

The serum phosphate, calcium, and albumin concentrations were measured at baseline and then every 3 months. Other serological parameters such as intact parathyroid