Phosphorus Additives in Food and their Effect in Dialysis Patients

Jaime Uribarri

Division of Nephrology, Department of Medicine, The Mount Sinai School of Medicine, New York, New York

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There is substantial epidemiologic evidence linking hyperphosphatemia and cardiovascular and all-cause mortality among dialysis patients (1,2). Therefore, control of hyperphosphatemia is a crucial element of the routine clinical care of dialysis patients.

Theoretically, control of serum phosphorus levels can be achieved by the right combination of decreased dietary phosphorus intake, decreased GI phosphorus absorption by phosphate binders, and increased phosphorus elimination via dialysis. However, the clinical reality is that despite the widespread use of high-efficiency dialyzers, new phosphorus binders, and usual nutritional education, the average serum phosphorus in dialysis patients remains higher than the levels recommended by practice guidelines, except in patients on long nocturnal hemodialysis (3). The lack of attention by practicing nephrologists to dietary phosphorus restriction in general, and more specifically the lack of awareness regarding the increasing consumption of processed foods rich in phosphate additives, may significantly contribute to limit the efficacy of the current interventions (4).

Estimation of the dietary intake of phosphorus should consider not only phosphorus contained in natural food, but also phosphorus added in processing food. In general, foods high in protein like meats, milk, eggs, and cereals are also naturally high in phosphorus and traditionally have represented the main source of dietary phosphorus (5). However, this is changing as phosphates are currently being added to a large and increasing number of processed foods, including meats, cheeses, dressings, beverages, and bakery products (6–8). As a result, and depending on the food choices, such additives may increase the phosphorus intake by as much as 1.0 g/d (7). Phosphorus in additives is more readily absorbed than that from foods naturally high in phosphorus; as a result, additives will have a greater effect on hyperphosphatemia than an equivalent amount of naturally occurring phosphorus (5). However, it is of note that Nutrition Facts labels do not include the amount of phosphorus from these additives.

It is not widely recognized that the currently available food composition tables in books or software programs do not accurately reflect this additional phosphorus (4,5). For example, when the phosphorus content of several foods measured by chemical analysis was compared with the phosphorus content estimated by three software programs, the latter consistently underestimated the phosphorus content by an average of 250 mg/d (9). When the comparison was made only with menus including six or more processed foods, the underestimation of phosphorus content was greater than 350 mg/d (9). Similar findings have been reported in different geographic areas including Japan (10), Spain (11), and Brazil (12). More recently, a group in Ohio made the same point by analyzing a variety of chicken products bought in stores in greater Cleveland (13). For every category of chicken products containing additives, the actual phosphorus content was greater than the content estimated from the nutrient database (13).

The main conclusion from the paper presented in this issue of *CJASN* is that enhanced meat and poultry products may contain additives that increase phosphorus and potassium content by as much as almost 2-fold and 3-fold, respectively. More importantly, most foods with phosphorus and potassium additives did not list them on their food label (14). The same authors have previously shown that the difference between measured phosphorus content in meat, poultry, and fish foods with or without processing was very significant (14.4 *versus* 9.1 mg of phosphorus/g protein) (15). These findings imply that better reporting of phosphorus content of foods by manufacturers could result in improved dietary phosphorus control without reducing protein intake to levels risking protein malnutrition (15). These results, together with the findings of other groups mentioned above (7–13), bring home the same strong message: phosphorus-containing additives are present in most meat products and significantly increase the phosphorus content of such products. Moreover, the lack of this information in the Nutrition Facts labels and in the available reference sources, as well as the variation between similar products, prevents patients and dietitians from accurately estimating food phosphorus content and, therefore, phosphorus intake. These findings have important implications for patients, clinicians, and policy-makers.

For the average dialysis patient, daily life is a constant struggle with dietary restrictions as well as with poor appetite and sometimes lack of energy to cook. Convenience and fast foods have many advantages for them: they are very accessible and tasty, are generally cheaper than healthier foods, and require

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Correspondence: Dr. Jaime Uribarri, One Gustave Levy Place, Box 1147, New York, NY 10029. Phone: 212-241-1887; Fax: 212-369-9330; E-mail: jaime.uribarri@mssm.edu

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very little or no preparation at all. Unfortunately, the important drawback is that they contain phosphorus additives, and patients should be instructed to limit their intake. The control and avoidance of processed foods is difficult for several reasons, some of which have already been mentioned. Another important but frequently ignored factor is that the availability of fresh foods may be limited for ethnic and racial minorities and for low-income patients, which make up a significant percent of the U.S. dialysis population. For example, the availability and cost of diabetes-healthy foods in a racial/ethnic minority neighborhood in East Harlem were compared with those in the adjacent, largely White and affluent Upper East Side in New York City (16). Overall, 18% of East Harlem stores stocked recommended foods, compared with 58% of stores in the Upper East Side. Only 9% of East Harlem bodegas (neighborhood stores) carried all items (*versus* 48% of Upper East Side bodegas), although East Harlem had more bodegas (16). A study in Cleveland screened the entrees at local restaurants for suitability for a renal diet and found that of 804 total entrees across 15 fast-food chains, 415 (52%) were acceptable according to traditional criteria and only 128 (16%) were also free of phosphorus-containing additives (17). On average, only one-sixth of entrees and side dishes at fast-food restaurants were suitable for dialysis patients and there were no suitable entrees or side dishes at several fast-food restaurants (17).

Despite all of the potential problems described above, it has recently been shown that nutrition education, focused on elimination of processed foods, is very feasible and effective in dialysis patients (18). In fact, Sullivan *et al.* (18) demonstrated that providing education to dialysis patients on avoiding foods with phosphorus additives when purchasing groceries or visiting fast-food restaurants led to a significant decline in serum phosphorus (on the average 0.6 mg/dl!) after 3 mo. This decrease of serum phosphorus in response to this modest dietary intervention should not be ignored because it is similar to the effect of small doses of phosphorus binders. As a comparison, in one study of over 200 dialysis patients randomized to take either calcium acetate or sevelamer for several months, an average fall of serum phosphorus by 1.5 mg/dl required 5.5 g/d of calcium acetate or 7.3 g/d of sevelamer (19). This is a large and costly amount of medications: three tablets three times daily for each!

Whether phosphorus is a passive marker for adverse events or a real toxin remains undetermined, but in recent years a similar relationship between high serum phosphorus and increased cardiovascular mortality has also been shown among nondialysis chronic kidney disease patients (20) and in the general population (21), forcing us to pay attention to serum phosphorus as a cardiovascular risk factor. Further decrease of serum phosphorus levels in the dialysis population will only be possible through actions at different levels. First, dialysis patients and their caregivers need to learn about the frequency of phosphorus-containing additives and how this leads to a significant increase in dietary phosphorus intake beyond that estimated from the natural content of phosphorus in food. Second, dialysis patients need to be advised to limit their intake of processed foods containing additives as much as possible. At a more general level, manufacturers should be required to include phosphorus content of food products on the Nutrition Facts labels, as it is currently required for other essential nutrients and minerals. The development of functional foods with low phosphorus content especially designed for chronic kidney disease patients is a particularly appealing idea to help diversify food choices in this population. In 2005, a low-phosphorus (116 mg phosphorus per 8 fl oz) 2% milk was introduced commercially (22), and hopefully more of these low-phosphorus foods will be available in the near future. Another important issue to consider is that addition of phosphorus goes hand in hand with addition of sodium because most of the phosphate is added as a sodium salt and sodium chloride is frequently added independently as a food preservative or for taste or appearance improvement. Therefore, avoidance of excessive sodium intake is another strong reason to recommend reduction of the intake of processed foods.

Disclosures

None.

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See related article, "Phosphorus and Potassium Content of Enhanced Meat and Poultry Products: Implications for Patients Who Receive Dialysis," on pages 1370–1373.