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Dietary style and acid load in an Italian population of calcium kidney stone formers

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Abstract *Background and aims:* Animal protein intake may cause an acid load that predisposes individuals to stones by influencing calcium and citrate excretion. These associations were not confirmed in recent studies. Therefore the present study was aimed to compare acid load of diet in stone formers and controls.
Methods and results: Participants to the study were 157 consecutive calcium stone formers and 144 controls. Diet was analyzed in these subjects using a software that evaluated nutrient intake from a three-day food intake diary. This software also estimated the potential renal acid load (PRAL, mEq/day). Twenty-four-hour urine excretion of ions and citrate was measured in stone formers.

Stone former diet had lower intake of glucose, fructose, potassium and fiber and higher PRAL in comparison with controls. The multinomial logistic regression analysis showed that stone risk decreased in association with the middle and the highest tertiles of fiber intake and increased in association with the highest tertile of PRAL. The linear multiple regression analysis showed that calcium excretion was associated with the sodium excretion and that citrate excretion was associated with the PRAL and animal protein intake in stone formers.
Conclusion: Our findings suggest that stone formers may undergo a greater dietary acid load sustained by a low vegetable intake and base provision. Dietary acid load does not appear as the main determinant of calcium excretion, but may promote stone risk by decreasing citrate excretion. Sodium intake may predispose to stones by stimulating calcium excretion.

Introduction

Dietary style plays an important role in kidney stone formation [1] and may explain the association of calcium nephrolithiasis with the metabolic syndrome, obesity and cardiovascular disease [2,3]. Intake of fluids, sodium and animal proteins have been implicated in the development of calcium kidney stones [4]. Therefore, an increase in fluid

Abbreviations: PRAL, potential renal acid load.

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intake and a reduction of sodium and animal proteins are usually recommended to patients to prevent calcium stone recurrence [5]. Animal protein intake leads to acid production, mainly through the metabolism of sulfuric acid from methionine and cysteine [4,6]. This may predispose individuals to stones through a tubular effect that enhances calcium excretion and decreases citrate excretion, thus acting on promoters and inhibitors of calcium salt precipitation. In addition, acid load may enhance calcium excretion by stimulating calcium delivery from bones [7–9]. Despite these findings, the relationship among diet with kidney stones remains controversial. Recent epidemiological surveys confirmed the association between nephrolithiasis and the dietary acid load [10], but no association with animal protein intake [10,11]. Furthermore, a short-term intervention study in healthy volunteers suggested that factors other than acid load explained the effect of a high-protein diet on calcium excretion [12].

Besides acid load, net acid excretion is influenced by dietary alkali content. Vegetables supply base-forming constituents that may counterbalance the acidifying effect of animal proteins [13,14]. The possible positive effect of vegetables on stone risk was observed in association studies [11] that also observed a positive correlation between vegetable intake and citrate excretion [15].

Dietary acid load may be calculated with a previously validated algorithm including both acids and bases generated from the diet. The algorithm calculates the potential renal acid load (PRAL) from the intestinal absorption rates of ingested protein, phosphate, magnesium, potassium and calcium [16]. Meat and cheese are the main source of dietary acids and therefore significantly increase PRAL whereas other dairy products like milk and yogurt do not significantly modify PRAL and vegetable foods move it to negative values. A recent study tested this algorithm in stone formers and showed an increased dietary acid load [10].

The present study estimated PRAL in calcium stone formers to analyze the contribution of dietary acid load and animal protein intake to the stone risk. It also investigated their contribution to the excretion of calcium and citrate.

Methods

One hundred and fifty seven stone formers and 144 controls of Italian origin were enrolled (Table 1). Stone formers were recruited at the outpatient stone clinics of the San Raffaele or San Paolo Hospitals in Milan since 2002 to 2012. Patients had a history of urinary emission or surgical removal of calcium-oxalate or -phosphate stones or had a radiologic examination positive for radiopaque stones. Participants to the study did not take drugs affecting calcium and electrolyte metabolism. Subjects with neoplasia history, or suffering from diabetes, bowel diseases, endocrine disorders or other diseases in addition to nephrolithiasis were excluded from the study. Their serum concentrations of creatinine, calcium and potassium had to be normal. Their urine pH had to be <5.5 at least in one of multiple morning spot urine samples collected after overnight fasting in different days to exclude patients with tubular acidosis.

Table 1 Nutritional findings in controls and stone formers. Organic base intake was the sum of citrate, malate and tartrate intake computed by diet analysis. Daily nutrient intake was estimated as the mean of 3 days.

	Stone formers	Controls	p
n (M/F)	157 (89/68)	144 (66/78)	0.07
Age (yrs)	48 ± 11.8	48 ± 10.1	0.93
Body weight (kg)	71.2 ± 14.5	68.8 ± 15.0	0.18
Calories (kcal/day)	2074 ± 569	2044 ± 564	0.65
Lipid intake (g/kcal)	36.5 ± 5.78	35.9 ± 5.94	0.39
Animal protein intake (g/kcal)	23.4 ± 6.76	22.7 ± 7.78	0.45
Vegetable protein intake (g/kcal)	12.8 ± 3.44	12.9 ± 3.41	0.93
Sugar intake (g/kcal)	44.2 ± 12.99	47.4 ± 14.07	0.044
Carbohydrate intake (g/kcal)	68.1 ± 15.04	66.1 ± 16.18	0.28
Potassium intake (mg/day)	2577 ± 747	2819 ± 865	0.01
Calcium intake (mg/day)	737 ± 333	814 ± 410	0.078
Phosphate intake (mg/day)	1139 ± 392	1160 ± 397	0.65
Magnesium intake (mg/day)	269 ± 95	281 ± 104	0.3
Organic base intake (mg/day)	2015 ± 1289	2286 ± 1405	0.082
Oxalate intake (mg/day)	166 ± 121.1	182 ± 157.3	0.32
Purine intake (mg/day)	146 ± 97.0	149 ± 90.8	0.81
Fiber intake (g/day)	14.6 ± 5.39	16.4 ± 6.47	0.008
PRAL (mEq/day)	12.7 ± 17.36	6.1 ± 14.65	0.0001

Controls were recruited from the Hospital personnel and Blood Transfusion Centre donors at San Paolo Hospital. They had negative personal and familial history of kidney stones, normal serum concentrations of creatinine and calcium and no evidence of diseases at physical examination.

Nutritional analysis was performed in patients and controls through the compilation of a three-day food intake diary fulfilled at least three months after urologic treatment of stones. Participants received instruction from the nephrologist on how to record consumed foods in the diary. They had to compile the diary in three non-consecutive days, being one of these days festive (Sunday or other). Each completed diary was reviewed by a dedicated nutritionist or dietitian who verified the reliability of the records in the presence of the patient. Portion size was evaluated using Scotti-Bassani photographic atlas of foods (www.scottibassani.it). Nutrient intake was estimated by a specific software (Dietosystem, DS Medica, Milan) including oxalate, electrolyte and mineral food content. This software determines the nutrient composition of every eaten food. The software database was previously extended in collaboration with the software developers, including recent data from national and international institutions' databases and from scientific papers [17]. This software also estimated PRAL (mEq/day) according to the methods previously validated and here reported [16]:

- PRAL = 0.49 × dietary proteins (g/day) + 0.0366 × dietary phosphate (mg/day) − 0.021 × dietary potassium (mg/day) − 0.026 × dietary magnesium (mg/day) − 0.013 × dietary calcium (mg/day);