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ARTICLE

Roswitha Siener

Impact of dietary habits on stone incidence

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Abstract Changes in dietary habits and lifestyle are suggested to contribute markedly to the rise in the prevalence and incidence of urolithiasis during the past decades. Insufficient fluid intake and diets rich in animal protein are considered to be important determinants of stone formation. Overweight and associated dietary pattern additionally contribute to the increasing incidence and prevalence of stone disease. Reduction of overweight through extreme fasting or high-protein weight-loss diets, e.g. Atkins diet, also appear to affect stone formation. Although there is evidence that changes in dietary habits can reduce urinary risk factors and the risk of stone formation, further randomized controlled clinical trials are necessary to evaluate long-term effects of dietary interventions on stone disease.

Keywords Dietary habits · Urinary stone disease · Urolithiasis · Dietary risk factors

Epidemiology

Numerous reports have suggested a marked increase in the prevalence and incidence of stone disease in industrialized countries during the past decades. In Japan, the prevalence increased from 4.0 to 5.4% within 10 years, corresponding to a rise of 35% [1]. The investigation of the frequency of urolithiasis in a village near Milan, Italy, revealed an increase in the prevalence of stone disease in men from 6.8% in 1986 to 10.1% in 1998, i.e. by 49% and in women from 4.9 to 5.8%, i.e. by 18% [2]. The prevalence of urolithiasis in the Unites States was estimated to be 5.2% during the years 1988–1994, compared to 3.8% from 1976 to 1980 [3]. In Germany, a marked increase in the prevalence from 4.0 to 4.7% and a rise in the incidence of stone disease from 0.54 to 1.47% was observed between 1979 and 2001 [4].

Analysis of the age at first stone episode indicated a high incidence of first occurrences in both men and women aged 25–50 years [4]. The high frequency of urolithiasis in patients at the most active stage of their careers supports the hypothesis that inadequate dietary habits and lifestyle might be important causative factors.

R. Siener
Department of Urology, University of Bonn, Sigmund-Freud-Str. 25, 53105 Bonn, Germany
E-mail: Roswitha.Siener@ukb.uni-bonn.de
Tel.: +49-228-2879034
Fax: +49-228-2874285

Drinking habits

A consistently low urine volume due to a low fluid intake or an increased respiratory-percutaneous water loss is an important risk factor in urinary stone formation. Evidence from epidemiological studies exists that adequate fluid intake is one of the most important dietary measures for the prevention of stone recurrences.

In a large prospective study of men, who had no history of kidney stones, an inverse association between fluid intake and the risk of urinary stone formation was observed during 4 years of follow-up [5]. After adjustment for other potentially confounding variables in the multivariate analysis, the relative risk for men decreased significantly from 1.0 in the lowest quintile (<1,275 ml/day fluid intake) to 0.71 in the highest quintile (≥2,538 ml/day fluid intake). This finding in men was consistent with results of a long-term prospective study among women where the risk of stone formation was found to be inversely related to fluid intake [6]. In the multivariate model, the relative risk for women with the highest fluid intake was 0.61 as compared with those with the lowest intake (1.0), a 39% reduction in risk.

The only randomized prospective trial on the impact of fluid intake as a preventive measure in urinary stone formation was performed by Borghi et al. [7]. Idiopathic first-time calcium oxalate stone formers were randomly assigned to two different groups. Patients in the intervention group were advised to increase fluid intake to at least 2 l/day, while patients in the control group received

no specific instructions. During a 5-year follow-up, the patients in the intervention group with significantly higher urine volumes experienced a significantly lower recurrence rate than the control group with no changes in fluid intake [7]. The study confirms that an increase in fluid intake to assure a consistent urine volume of at least 2 l/day is the initial therapy for the prevention of stone recurrences.

Conflicting evidence exists regarding the effect of various beverages on the risk of urinary stone formation. Assessing the data from an epidemiological study, Curhan et al. [8] observed no association between the intake of sugared cola and the risk for stone formation in men, while a clinical trial in healthy subjects conducted by Rodgers [9] suggested an increased risk in men due to a significant increase in urinary oxalate excretion by 60 µmol/24 h after consumption of 2.0 l of regular (non-diet) cola beverage.

In two prospectively conducted studies, Curhan et al. [8, 10] showed that each 240 ml serving of caffeinated coffee was associated with a 10% decrease in risk of stone formation in men and women. A recent epidemiological study by Goldfarb et al. [11] supported the protective effect of coffee for stone disease. However, no explanation is provided for this finding. In a recent interventional trial, Massey and Sutton [12] examined the acute effect of caffeine consumption on urine composition and risk of stone formation in 39 normocalcaemic patients with calcium stones. The subjects received 6 mg caffeine/kg lean body mass in 180 ml of warm deionized water. The doses ranged from 250 to 400 mg caffeine, the equivalent of 11–17 ounces (330–510 ml) of brewed coffee. Caffeine loading resulted in an increased urinary calcium/creatinine ratio and an elevated Tiselius risk index. Since caffeine induces hypercalciuria, affects hydration and may aggravate hypertension, patients should be recommended to consume caffeinated beverages in moderation and to drink water before or along with the coffee.

Dietary protein and purines

Data from epidemiological studies provide evidence for a strong correlation between the incidence of stone disease and consumption of animal protein [5, 13]. In a cohort of men, who had no history of stone disease, intake of animal protein was directly associated with the risk of stone formation. The relative risk for men with the highest intake of animal protein (≥77 g/day animal protein) as compared with those with the lowest (≤ 50 g/day animal protein) was 1.33, corresponding to a 33% increase in risk [5].

A high intake of animal protein, as consumed in many industrialized countries, may affect urinary calcium excretion by several different mechanisms. A high protein diet increases endogenous acid production that may require buffering from bone, thereby increasing calcium resorption [14, 15]. Moreover, increasing dietary protein is related to increases in glomerular filtration rate (GFR) [16] and decreases in renal reabsorption of calcium from distal tubular cells [15]. In hypercalciuric patients the calciuric effects of a high protein intake may be even greater [17].

A randomized prospective trial in 120 men with recurrent calcium oxalate stone disease clearly demonstrated that a diet characterized by normal calcium but reduced animal protein is more effective than the traditional low-calcium and unrestricted protein intake for the prevention of stone recurrences [18].

The consumption of protein-rich foods of animal origin is mostly associated with an increased intake of fat, cholesterol and purines. Hyperuricaemia and hyperuricosuria are suggested to be the most important risk factors for the formation of uric acid stones and may contribute to the development of calcium oxalate urolithiasis. A recent epidemiological trial conducted by Choi et al. [19] revealed an enhanced incidence of gout among men with increasing intake of meat and seafood. The risk of gout decreased with increasing consumption of dairy products and remained unaffected by purine-rich foods of vegetable origin.

Overweight and obesity

Recently, overweight was identified to be a crucial risk factor for stone formation. Analysis of 527 idiopathic calcium oxalate stone formers showed that 59.2% of the men and 43.9% of the women were overweight or obese [20]. The median number of total stone episodes was significantly higher in overweight or obese (BMI≥25.0 kg/m^2) versus normal weight men (BMI 18.5–24.9 kg/m^2) but not in women. Multiple linear regression analysis revealed a significant positive relationship between BMI and urinary uric acid, sodium, ammonium, and phosphate excretion and a negative correlation between BMI and urinary pH among both genders.

A prospective study conducted by Taylor et al. [21] confirmed that overweight and weight gain increase the risk of stone formation. In particular, urinary pH was found to be inversely related to body weight among stone patients [22]. Gillen et al. [23] observed that stone history is associated with lower GFR among overweight persons (BMI > 27 kg/m^2), and may therefore reduce kidney function. Further investigations are needed to examine the responsible mechanisms.

Despite the growing popularity of high-protein weight-loss diets, e.g. Atkins and South Beach diet, concerns about potential adverse health effects exist. A study in ten healthy individuals compared the effects of a usual non-weight-reducing diet, then a severely low-carbohydrate high-protein induction diet for 2 weeks, followed by a moderately low-carbohydrate high-protein maintenance diet for 4 weeks [24]. Urinary pH and citrate excretion decreased, whereas undissociated uric acid increased significantly during the high-protein induction

and maintenance diets compared with the usual diet. Estimated calcium balance decreased, since the increase in urinary calcium excretion was not compensated by an increase in fractional intestinal calcium absorption. Generation of an augmented urinary acid load by a diet rich in sulphur-based amino acids may therefore increase the risk for stone formation and bone loss.

Dietary intervention

A recent trial evaluated the effect of dietary intervention on urinary risk factors of recurrence in calcium oxalate stone formers [25]. One hundred and seven recurrent calcium oxalate stone patients collected 24-h urine on their habitual, self-selected diets and on a balanced standardized diet according to the recommendations for calcium oxalate stone formers. An insufficient fluid intake and an increased intake of alcohol and protein were identified as the most important dietary risk factors of the patients on their usual dietary habits. The shift to a nutritionally balanced diet according to the recommendations for calcium oxalate stone formers significantly reduced the stone-forming potential.

Conclusions

Inadequate dietary habits play an important role in the development of urolithiasis. Insufficient fluid intake and diets rich in animal protein are suggested to be important determinants of stone formation. Overweight and obesity additionally contribute to the increasing incidence and prevalence of stone disease. However, extreme fasting or high-protein weight-loss diets, e.g. Atkins diet, also appear to affect stone formation. Ongoing research is needed to address and resolve controversies surrounding the roles of different beverages and nutritional factors in the development of calcium stones. Further randomized controlled clinical trials are necessary to evaluate long-term effects of dietary interventions.

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