

Urolithiasis

Review: The Importance of Diet in Urinary Stones

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Numerous investigations have shown that an unphysiological dietary regimen in the form of inadequate fluid intake or excessive consumption of foodstuffs containing lithogenic substances may play a crucial part in the formation of urinary stones. We have repeatedly demonstrated during the last few years that the high-risk composition of the urine found in many patients with urinary stones can be rectified by adopting a physiological mode of nutrition [6, 7, 46, 48]. In this context the word "diet" must be understood as defined in the major German dictionary, the "Duden" as correct nutrition or as normalization of the mode of nutrition in keeping with the recommendations of the German Society for Nutrition (DGE). This means adequate intake of fluid and foodstuffs with avoidance of excessive consumption of lithogenic substances. This definition of diet must be made absolutely clear to refute the prejudices which are a legacy from the days of unphysiological dietary restriction.

General Recommendations

As the pathogenesis of urinary stones is nearly always multifactorial, general recommendations should, as far as possible, take all the risks into account and should be aimed at avoiding the concurrence of risk factors.

Fluids

The need for *adequate fluid intake* is undisputed. Its purpose is to dilute the urine and hence to lower the concentration of lithogenic substances. Our investigations carried out under standardized conditions have shown that a daily intake of 2–2.5 litres is sufficient, certainly for patients who have no tendency to fluid retention. Cardiovascular problems may necessitate some restriction of fluid intake, whereas patients with pronounced fluid losses may require larger

Table 1. General recommendations on fluid intake, diet and mode of life for urinary stone formers

1. Fluid intake

- a) 2–2.5 litres in 24 h
evenly spread over the day
(less for patients with heart and circulatory diseases – ask your doctor!)
- b) Unlimited tap water, fruit and herbal teas (including kidney and bladder teas), apple juice
- c) Coffee, tea and alcoholic drinks should be cut down as much as possible

2. Diet

- a) Normal mixed diet or vegetarian diet
- b) Not more than 100 g of animal protein (fish, meat) daily
- c) Reduce fat and sugar consumption
- d) Not more than 5 g cooking salt and table salt daily

3. Mode of life

- a) Frequent small meals
- b) Avoid purgatives whenever possible (regulate the bowels by dietary fibre, lubricant agents, etc.)
- c) Adequate physical exercise
- d) Adequate recreation and sleep

volumes; fluid balance can be checked, if necessary, by regular weighing.

It is also important that fluid intake should be evenly spread over the day and that an adequate volume should be taken before going to bed, and if necessary during the night as well, so as to avoid concentration peaks of lithogenic substances.

Patients invariably ask what fluids they may consume and whether there are any restrictions.

We recommend unrestricted fluid intake of *tap water* since no correlation between the hardness of water and the prevalence of urinary stones has ever been proved and because the tap water in the German Federal Republic does

not contain other substances in amounts sufficient to create any risk of urolithiasis [47].

We also recommend all kinds of *fruit and herbal teas* prepared with tap water, including special kidney and bladder teas [4, 5, 18].

We also permit unrestricted consumption of *apple juice*, since our investigations carried out under standardized conditions showed no evidence that it affects the composition of the urine.

Avoidance is also required on the consumption of coffee, conventional tea and alcohol. Among the patients we investigated, 76% stated that they drank *coffee* every day. About one-third of these patients drank considerably more than 750 ml/day [46]. Excessive consumption of coffee causes autonomic nervous stimulation [8] with consequent elevation of basal metabolic rate; this results in raised excretion of uric acid and a shift of urine pH towards the acid side. In view of these facts, all patients who tend to form urinary stones should be advised not to drink more than three cups (450 ml) of normal strength coffee daily.

The same applies to *tea*, which was drunk daily by 21% of our patients. About one-third of these patients drank more, sometimes considerably more, than 750 ml/day [46]. Besides raising uric acid excretion, tea also causes an increase in oxalic acid output. Churchill et al. [10] state that this is of no importance when normal amounts of tea are consumed, but must be taken into account in those who drink tea to excess. For example, Zarembski and Hodgkinson [51] demonstrated that a daily intake of five cups of conventional tea was not unusual in England and that this represented 75 mg of oxalic acid, roughly equivalent to 60% of the total daily oxalic acid intake.

Alcohol consumption requires special attention. In West Germany the rise in the incidence of urinary stones is more closely correlated with the rise in alcohol consumption than with other trends, such as the rising consumption of animal protein, carbohydrates or calcium. In our own study 53% of patients stated that they drank alcohol every day. 43% of these patients drank beer every day. Of these, 55% drank up to 700 ml daily, 29% drank 1 litre exactly and 16% between 1 and 2 litres [46]. Fellström et al. [11] took dietary histories from their patients and found that their patients with urinary stones consumed almost twice as much alcohol as healthy controls.

A high alcohol intake leads to raised levels of blood lactate. This at first lowers the renal excretion of uric acid and causes hyperuricaemia, but subsequently leads to an increase in uric acid excretion. In keeping with these findings, Zechner [53], and Zechner and Scheiber [52] reported correlation between rising alcohol consumption, increased output of uric acid in the urine and a rise in the incidence of urate-containing stones.

From these facts it is clear that patients with a tendency to form urinary stones must be advised to restrict their alcohol consumption not only because of the risks of addiction but also because alcohol may play some part in the pathogenesis of stones.

Diet

Robertson et al. [36, 37] and Brockis et al. [9] have shown that patients taking a *vegetarian diet* excrete less calcium and less oxalic and uric acids than patients on an ordinary diet. Furthermore, the incidence of urinary stones and the tendency to recurrence is considerably lower among vegetarians than in the general population. However, before making dietary recommendations along these lines, it would be necessary to make sure that a vegetarian diet was acceptable and that the patient could make the necessary adjustments in his domestic and working life.

Our rule is to recommend a *normal mixed diet*, but to avoid excessive consumption of any lithogenic substances in drinks or foodstuffs.

We consider it most important to recommend an adequate intake of *vegetable fibre roughage* in the form of wholemeal bread, fruit and vegetables. Our advice is based on the observations of Griffith et al. [17] and Fellström et al. [13], who found that patients with a tendency to form urinary stones had a lower intake of dietary fibre than controls. Power and Nelson [29] were unable to confirm this. However, in 1984 the German Society for Nutrition drew attention to the decline in the intake of dietary fibre and the associated rise in bowel diseases. Apart from these general considerations, of relevance to all patients with urinary stones, there is another fact which seems to be of importance, at least to patients who tend to form calcium-containing stones, namely that an increased intake of dietary fibre lowers the excretion of calcium in the urine [26, 33, 42, 50].

Recommendation for restriction of the intake of animal protein are based on the observations of Robertson et al. [35] and Iguchi et al. [21]. They found that the incidence of urinary stones was clearly correlated with a relative increase in the consumption of animal protein, though not with total protein intake.

The German Society for Nutrition [11] has recorded a steady increase in the consumption of pork; between 1950 and 1979 it rose from roughly 8 kg to roughly 50 kg per person per year. Yet the consumption of fish, poultry and beef remained approximately the same. In their 1984 report the DGE notes that protein intake remains more than sufficient.

As regards pathogenesis, it is significant that excessive protein intake causes rises in the excretion of calcium [1, 2, 9, 12, 19, 21, 23, 24, 36], oxalic acid [36] and uric acid [19, 25, 36, 54].

Iguchi et al. [21] found that excessive protein intake given to experimental animals caused metabolic acidosis with a definite fall in urine pH, together with hypocitraturia and hypercalciuria. Their work confirmed the findings of Welshman and McGeown [49] and of Schwille et al. [40], who had observed a decrease in citrate excretion in patients with urinary stones receiving high protein diets. Arora et al. [3] pointed out that methionine increases calcium excretion, while glycine, hydroxyproline and tryptophan increase

oxalic acid excretion and ribonucleic acid increases uric acid excretion. Tschöpe et al. [45] found that methionine given by mouth produced hypercalciuria, a low urine pH and a decrease in urinary citrate. Oral administration of glycine in high doses led to mild hyperoxaluria, but this was not found after intravenous injection of glycine.

On the basis of previous knowledge, Finlayson [14] recommended that meat consumption should be reduced to 170–220 g daily. In the light of more recent observations – notably the marked increase in calcium and uric acid excretion produced by the consumption of 150 g of liver [19] – we now recommend subjects with a tendency to urolithiasis not to consume more than 100 g of meat or fish daily.

Advice against excessive consumption of *fat* or *sugar* is based primarily on the wider problems of obesity and secondly on certain specific observations.

For example, Griffith et al. [17] noted that urinary stone formers had a higher *fat* consumption than healthy controls. Goldschmidt et al. [16], working in Alsace, found that a high intake of unsaturated fatty acids was more closely correlated with urinary stones than was consumption of protein or sugar. In Japan, Iguchi et al. [21] also noted that the rising incidence of urinary stones was paralleled by a substantial increase in the consumption of fats and oils. On the other hand, according to the latest report from the DGE [11], total fat consumption in West Germany has remained more or less unaltered in the last few years.

Carbohydrate consumption in West Germany is relatively high [11] and in the last few years it has risen steadily but slowly. In 1980/81 the average for men was 380 g and for women 293 g daily. In Great Britain Power and Nelson [29] found that the average carbohydrate intake among their patients with urinary stones was 322 g daily. Iguchi et al. [21] give similar figures for Japan. In Laos Goldschmidt et al. [16] found that daily carbohydrate consumption averaged 392 g and correlated more closely with the incidence of urinary stones than did protein or fat intake.

Our advice to avoid excessive consumption of sugar is based partly on the observation of Rao et al. [30] regarding glucose-induced hypercalciuria, and partly on the report of Schuille et al. [41], who found that in patients with recurrent calcium urolithiasis, in contrast to healthy controls, there was hyperoxaluria and hypercalciuria of considerable intensity during the 3 h postprandial period after an oxalate-free test meal.

Our recommendation that *sodium chloride* intake should be limited to 5 g daily is based primarily on the conclusions of the DGE [11], namely that salt consumption in West Germany – at present roughly 15 g per person per day – is too high. The aim of the restriction is to lower the risk of developing high blood pressure and it seems to us absolutely necessary for patients who already have signs of labile or manifest hypertension. Further grounds for the recommendation are to be found in the fact that increased sodium intake leads to a rise in calcium excretion in healthy subjects and urinary stone patients alike [15, 27, 32, 38, 39, 44].

Table 2. Special dietary recommendations for calcium oxalate stone formers

Calcium oxalate stones

Fluids

unrestricted:

tap water, fruit and herbal teas (including kidney and bladder teas), fruit juices

restricted:

not more than 300 ml daily of milk or spring or mineral water containing more than 100 mg calcium/litre. As little as possible – blackcurrant juice, coffee, tea and alcoholic drinks

Diet

unrestricted:

normal mixed diet, or vegetarian diet

restricted:

not more than 100 g of fish and/or meat, not more than 50 g of cheese, rhubarb or spinach daily

Special Recommendations

Besides the general recommendations set out above, our patients also receive special recommendations depending on the composition of their stones and the clinical findings in each individual. Here I intend to discuss only those matters which have not been dealt with under the general recommendations.

Calcium oxalate stone formers are allowed to drink fruit juices without restriction, with the exception of blackcurrant juice, which acidifies the urine. A shift of urine pH into the neutral range, as may be caused by citrus fruit juices, is not disadvantageous, for the reason that it decreases the danger of uric acid precipitation and the tendency to heterogeneous nucleation.

Limitations on the intake of milk, high calcium mineral waters and cheese are intended as safeguards against excessive calcium intake. In individual instances advice must of course be given on the upper limit of calcium intake. In this connection it must not be forgotten that some mineral waters contain as much as 900 mg of calcium per litre. Even though the ion activity product in the urine will usually be lowered by urinary dilution [22] consumers of these high calcium mineral waters are exposed to the risk that the dilution effect may be overwhelmed by a cumulative effect if the patient happens at the same time to be taking a diet with an extremely high content of lithogenic substances [47, 48].

One point which deserves special emphasis is the dietary advice regarding rhubarb and spinach. The validity of this recommendation is underlined by the work of Hesse et al. [19], who found that a test meal containing ordinary portions of these foods was followed by surprisingly high excretion peaks of oxalic acid.

Table 3. Special dietary recommendations for calcium phosphate stone formers

Calcium phosphate stones

Fluids

unrestricted:

tap water, fruit and herbal teas (including kidney and bladder teas), apple juice, blackcurrant juice

restricted:

so far as possible avoid citrus fruit juices (oranges, mandarins, grapefruit, lemons) and also coffee, tea and alcoholic drinks

not more than 300 ml daily of milk or spring or mineral water containing more than 100 mg/l of calcium

Diet

unrestricted:

normal mixed diet or vegetarian diet

restricted:

not more than 100 g of fish and/or meat and 50 g of cheese daily

not more than one orange (1–2 mandarins), grapefruit or lemon daily

Table 4. Special dietary recommendations for uric acid and cystine stone formers

Uric acid stones and cystine stones

Fluids

unrestricted:

tap water, spring and mineral water, fruit and herbal teas (including kidney and bladder teas), fruit juices (in particular orange, mandarin, grapefruit and lemon juice)

restricted:

so far as possible avoid blackcurrant juice, coffee, tea and alcoholic drinks

Diet

unrestricted:

normal mixed diet or vegetarian diet, citrus fruits

restricted:

not more than 100 g of fish (anchovies or sardines less!) and/or meat (offal less!) daily

For *calcium phosphate stone formers* we recommend blackcurrant juice because of its urine acidifying effect, whereas we limit the intake of citrus fruits and their juices because of their alkalinizing effect on the urine and the associated danger of calcium phosphate precipitation. We also recommend restrictions on milk, cheese and high calcium containing mineral waters, underlining the necessity to avoid excessive calcium intake.

Table 5. Special dietary recommendations for mixed urinary stone formers

Mixed stones

Fluids

unrestricted:

tap water, fruit and herbal teas (including kidney and bladder teas), apple juice

restricted:

so far as possible avoid coffee, tea, alcoholic drinks, blackcurrant juice and orange, mandarin, grapefruit and lemon juice

not more than 300 ml daily of milk or spring or mineral water containing more than 100 mg/l of calcium

Diet

unrestricted:

normal mixed diet or vegetarian diet

restricted:

not more than 100 g of fish and/or meat and 50 g of cheese daily

not more than one orange, mandarin, grapefruit or lemon daily

From the foregoing our special recommendations for *uric acid stone formers* do not require any further explanation.

Our special recommendations for *cystine stone formers* are practically identical. Although the urinary output of cystine in patients with this inborn error of metabolism is indeed unaffected by diet, these patients can be helped by urinary dilution and dietary measures. The aim is to prevent acidification of the urine or actually to alkalinize it and hence to improve the solubility product.

Lastly, the special recommendations for *mixed stone formers*, shown here, are of value for patients with combined pathogenesis or for those with urinary stones made up of several components in roughly equal proportions.

In summary it may be said that our general and special recommendations for preventing recurrent stone formation are simple and effective. Their efficacy has been clearly demonstrated by regular follow-up studies [43]. Rao et al. [34] also demonstrated that urinary excretion of calcium, oxalic and uric acid can be effectively diminished by a diet which is perfectly acceptable to patients. As shown by Pak et al. [28] many patients can be protected against recurrent stones by adequate fluid intake and dietary measures alone. Hosking et al. [20] achieved freedom from recurrences over an average observation period of five years in roughly 60% of their idiopathic calcium stone formers simply by high fluid intake and by stopping excessive consumption of food-stuffs which encourage urinary stone formation. The willingness of patients to comply with an acceptable diet has been demonstrated by ourselves [43] and by Rao et al. [31]. Recurrent stone formers have the strongest possible motivation and dietary advice should be the first step towards pre-

vention of recurrences, although it will often need to be supplemented by pharmacological treatment, as recently reiterated by Pak et al. [28].

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