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ARTICLE

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Is prevention of stone recurrence financially worthwhile?

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Abstract This review shows that the cost of relying solely on minimally-invasive urological procedures for removing stones when patients return with recurrent stones is considerable and is significantly greater that that incurred by screening already proven recurrent stone-formers to identify the risk factors that are causing their stones and then instituting prophylactic measures to prevent stone recurrence. In the UK, at 1998 prices (when the original survey was carried out) for every stone episode prevented, there is a potential saving of almost £2,000 to the local Health Authority concerned. In spite of this, many Health Authorities have taken the liberty to discontinue comprehensive stone screening within the past 20 years under the mistaken supposition that minimally-invasive techniques for removing stones have "solved the stone problem". At UCLH in London where such a comprehensive scheme has been in place for the past 8 years, savings of up to £250,000 per year can be made by identifying the particular lifestyle as well as the epidemiological, metabolic and nutritional risk factors involved in a given patient and then instituting appropriate measures to prevent further stones.

Keywords Stone recurrence · Extracorporeal shock-wave lithotripsy · Percutaneous nephrolithotomy · Open surgery · Cost

Introduction

The prevalence of urolithiasis has been generally increasing in most countries over the past 100 years although, during that time, there have been occasional "peaks" and "troughs" in the incidence rate that have coincided with periods of economic expansion and recession respectively [1]. Stones occur more commonly in affluent, industrially developed countries and less frequently in countries whose economies are weaker and more tied to agriculture. Indeed, the life-long expectancy of forming stones in men follows the pattern of increasing Gross Domestic Product in countries across the world (Fig. 1). This growing problem has brought with it a financial challenge to Health Authorities as to how best to manage the situation.

During the past 25 years, following the advent of minimally-invasive techniques for removal of urinary calculi, the emphasis on the medical management of patients with stones has become largely neglected. The undoubted success of extracorporeal shock-wave lithotripsy (ESWL), percutaneous nephrolithotomy (PCNL), ureteroscopy (URS) and flexible ureterenoscopy (FURS) for the removal of stones [2], coupled with the fact that lasting side-effects from the use of these procedures appear to be minimal, have lulled many urologists into the belief that the problem can be managed solely by these means. As a consequence of these advances, open surgery has become a rare event in most Urology departments and, along with it, the routine investigation of stone patients to identify the cause(s) of their stones. In most hospitals within the UK, only the minimum number of biochemical investigations are now carried out, usually consisting of a blood sample, to exclude the possibility of hypercalcaemia or hyperuricaemia, and a spot urine sample for checking pH and for detecting blood, protein and sugar. A mid-stream urine sample is taken for microbiological screening if a urinary tract infection is suspected.

The reason for the demise of comprehensive stone screening is not just attributable to the advances in urological technology but also to the opportune cost-cutting practised by Health Authorities that has followed in its wake in most countries where Health Service budgets are constantly under scrutiny. It has been assumed that financially it is more economical to treat stone-formers using the new technologies, whenever their stones recur, than to spend money on investigating

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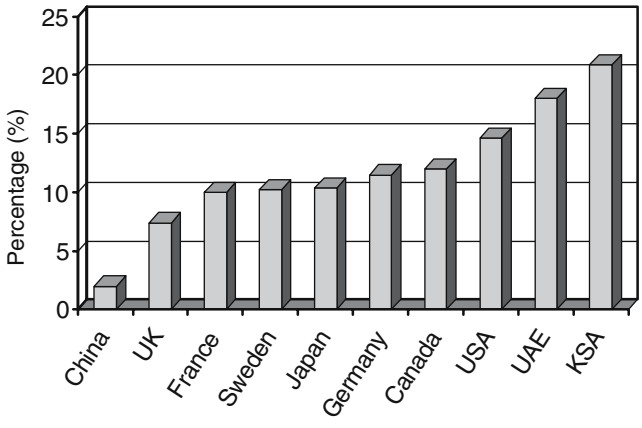

Fig. 1 The life-expectancy of forming stones in men aged 60–70 in various countries. (*UAE* United Arab Emirates; *KSA* Kingdom of Saudi Arabia)

the patients to find out the cause(s) of their stones and then to treat them prophylactically to prevent them from forming further stones. The question is—is this supposition correct?

Although ESWL, PCNL, URS and FURS may be the procedures of choice for the removal of stones, they do not prevent the recurrence of stones since there is nothing inherent in these techniques that will treat the underlying cause(s) of stone-formation in most patients. The exceptions are those cases where anatomical obstruction is a significant factor in their stone-formation and where this is corrected during the course of the procedure to remove the stone. The fact is that without medical intervention, the natural history of the disease clearly shows that the vast majority of patients will form at least one more stone after their first—38% within 3 years rising to 74% within 10 years and to 98% within 25 years [3]. Furthermore, examination of the collected follow-up data after ESWL and PCNL from 29 centres worldwide shows that the recurrence rate of stone-formation at 3 years is slightly higher than with the former open surgical and Dormia basket techniques (Fig. 2). This is hardly surprising since, in a significant proportion of cases, fragments are left behind in the urinary tract that, in the majority of cases, will eventually act as foci for further stone-formation [2].

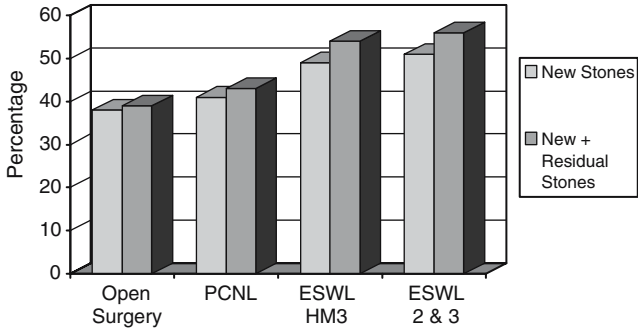

Fig. 2 The percentage of patients who have a least one stone recurrence within 3 years of various urological procedures for removing their first stone. The data are taken from 29 studies cited in references [2] and [3]

Cost of management of patients with stones

Continuing to allow patients to form stones and removing them by means of new technologies without providing any form of medical management other than the classical Hippocratic advice to "drink more fluids" is, in the long run, an expensive way to manage the problem [4–7], although it is considerably less expensive than it would be if urologists still had to remove stones by open surgery. The average stone patient in the population as a whole will have between three and four stone episodes during his/her life. However, the typical patient currently attending a major stone centre will already have had an average of 2.7 stone recurrences over a 13.6-year period since their first stone (i.e. a total of 3.7 episodes). If the patient continues to follow the natural history of the disease, he/she will go on to have a total of seven stone episodes (including the first) over 30 years, this being the average length of history of patients with stones. Since about 60% of episodes require intervention involving either ESWL, PCNL, URS or FURS or various combinations of these procedures, this means that the average stone-former at a major stone centre will have 4.2 episodes during his/her life treated at an estimated average cost (at current prices) of £2,270 per episode. This covers the cost of the urological procedure(s) plus those of three outpatient visits and a minimal biochemical screen (a blood sample and spot urine). Thus, the total cost to the Health Service of the average stone patient attending stone clinics at a major referral centre over 30 years at 1998 prices is calculated to be £9,534 per patient. The projected total cost to the Health Service of the estimated 700,000 stone patients in the population (1.2%), each of whom, on average, will have 3.5 stone episodes (of which 60% will require urological intervention) over the next 30 years, is a staggering £3.34 billion [6] based on 1998 prices!

Table 1 shows the projected costs of managing each patient according to the follow-up system described below consisting of an annual outpatient visit and a biennial biochemical screen. The proposed objective of this scheme is to treat each patient according to his/her specific risk factors in order to reduce the rate of stone recurrence. Treatment would consist of conservative management wherever possible; drugs would be used only where necessary.

The effect of the overall cost of managing stone patients attending a major stone centre and reducing their rate of stone recurrence to various fractions of the original recurrence rate is shown in Table 1. Also shown are the combined projected savings for the average of 1,680 stone patients who attend the various Urology and

Table 1 Projected cost of various courses of management for stone patients over 30 years at 1998 prices

Course of stone management	Total stone recurrences over 30 years[a]	Total stone episodes over 30 years including first stone[a]	Cost per patient over 30 years (urology + screen) (£)[b]	Cost per patient over 30 years (urology + screen + prophylaxis) (£)[c]	Projected annual savings at a major stone centre (£)[d]
Minimal investigation with no prophylaxis	6	7	9,534	N/A	N/A
Full initial screen + annual follow-up + biennial screen + prophylaxis to lower recurrence to $^{1}/_{2}^{e}$	3	4	8,130	8,380	64,624
Full initial screen + annual follow-up + biennial screen + prophylaxis to lower recurrence to $^{1}/_{3}^{e}$	2	3	6,930	7,180	131,824
Full initial screen + annual follow-up + biennial screen + prophylaxis to lower recurrence to $^{1}/_{5}^{e}$	1.2	2.2	5,970	6,220	185,584
Full initial screen + annual follow-up + biennial screen + prophylaxis to lower recurrence to $^{1}/_{10}^{e}$	0.6	1.6	5,250	5,500	225,904

[a]Based on actual recurrence rate of stone patients attending the stone clinics at a major referral centre
[b]Based on 60% episodes requiring urological intervention costing £2,270 per episode, a full initial screen costing £180, outpatient visit costing £65 and biennial screen costing £80
[c]Based on costs of urological intervention + biennial screen + average of £250 for drug treatment for every patient over 30 years
[d]Based on average of 1,680 stone patients attending the stone clinics at a major referral centre per year
[e]Based on reduction of the recurrence rate to $1/n$ of original basal untreated rate

Nephrology stone clinics at a major referral centre each year. Table 1 shows that considerable annual savings to the Health Service can be made by introducing a more comprehensive screening and follow-up system for the management of patients with stone compared with a system of minimal screening without any medical management. It should be noted, however, that the amount saved per patient decreases as the average basal recurrence rate in the patient population falls, such that if the screening and management system were applied to the entire stone population of the UK, savings would only be made if the stone recurrence rate were reduced to less than 10% of the basal value of 2.5 recurrences per patient after the first episode. Thus, the proposed system is financially viable only if it is applied to recurrent stone-formers who are forming stones at an average rate of more than one episode every 9 years. By this criterion, patients who have formed only a single stone are excluded from the proposed screening protocol along with those patients who have very low recurrence rates [8]. The bottom line is that for every episode of stone recurrence that is prevented by screening and appropriate management, the Health Authorities will save almost £2,000 in the UK [6], $2,158 in the USA [4] and a 30% reduction in the cost of stone management in Germany [5].

Prophylactic management of stone-formers

In the majority of cases, a comprehensive metabolic screen such as STONESCREEN [9], will separate those patients who have stones that are secondary to (a) a urinary tract infection [with stones consisting of magnesium ammonium phosphate (MAP) and/or CaP], (b) primary hyperparathyroidism (CaOx/CaP stones), (c) distal renal tubular acidosis (“pure” CaP stones), (d) primary or enteric hyperoxaluria (CaOx stones), (e) one of a number of disorders of purine metabolism [in which the patients may form either uric acid, xanthine or 2,8-dihydroxyadenine stones depending on the disorder] or (f) cystinuria (cystine stones). All patients in these categories will either require specific medication [10–12] or surgical intervention in order to correct the underlying disorders that are responsible for the changes in urine composition that lead to the increase in their risk of forming stones (Table 2). The formation of iatrogenic stones can usually be halted by good hydration and by stopping treatment with the particular drug concerned. Between them, secondary stone-formers account for about 15–20% of all patients with stones in the UK.

This leaves about 75–80% of patients with so-called “idiopathic” stones consisting of UA, UA/CaOx, CaOx,

Table 2 Medical treatment of urinary stone disease

Type of stone-former	Treatment
2,8-Dihydroxyadenine	High fluid intake (>3 l/day) + Allopurinol (300 mg/day)
Silica	Discontinue magnesium trisilicate ingestion
Xanthine	Hereditary: high fluid intake + oral alkali (urine pH >7.4) Iatrogenic: withdraw Allopurinol
Cystine	High fluid intake (>3 l/day) + oral alkali (urine pH >7.5) or D-penicillamine (2–4 g/day) or α-mercaptopropionylglycine (2–3 g/day)
Uric acid	High fluid intake (>2.5 l/day) + oral alkali (urine pH >6.2) or Allopurinol (300 mg/day) or reduce purine intake
Infected	High fluid intake + antibiotics + oral acid (urine pH <6.2)
Calcium Idiopathic	High fluid intake + dietary advice or thiazide diuretics (10 mg Bendrofluazide/day) or phosphate supplements (1–1.5 g P/day) or magnesium supplements (500 mg Mg/day) or potassium citrate (20 mEq tds)
Primary hyperparathyroid	Parathyroidectomy or, if contraindicated, high fluids + oral acid
Hereditary hyperoxaluric	High fluid intake (>3 l/day) + pyridoxine (400 mg/day)
Enteric hyperoxaluria	High fluid intake + low oxalate/high calcium diet or liquid potassium citrate
Renal tubular acidotic	High fluid intake + thiazides or potassium citrate
Medullary sponge kidney	Treat as for idiopathic
Corticosteroid-induced	Discontinue corticosteroids: treat as for idiopathic
Sarcoidosis	High fluid intake
Milk–alkali syndrome	Discontinue alkali and moderate calcium intake
Vitamin D intoxication	Discontinue vitamin D: high fluid intake
Immobilisation	High fluid intake: remobilise as far as possible: treat any urinary tract infection with antibiotics
Iatrogenic	Discontinue drug concerned as far as possible and replace with alternative therapy + high fluid intake

CaOx/CaP or CaP. In the UK, "pure" UA and "pure" CaP stones between them account for only about 10% of all stone-formers. In the vast majority of the remainder, dietary, absorptive and renal factors are responsible for the combinations of urinary risk factors that lead to abnormal biochemical risks of forming stones (P_{SF}) [9]. Conservative treatment consists in advising the patients to correct their dietary pattern in order to reduce the biochemical risk of stones in their urine [13]. This is achieved by an analysis of the data obtained from URINESCREEN and DIETSCREEN [9]. Treatment will typically involve advice on the need to observe one or more of the following: (a) increase fluid intake (as tap water, mineral water or low calorie fruit squash), (b) reduce intake of animal protein and purine, (c) minimise the intake of high oxalate-containing foods, (d) optimise dietary calcium depending on the calcium status of the patient, (e) reduce the intake of salt and salty foods, (f) reduce the intake of refined sugars, or (g) increase the consumption of fruit, vegetables, brown bread and unsweetened cereals in order to augment the dietary intakes of fibre and magnesium, both of which are potentially protective factors against stone-formation.

The main problem with any form of preventative therapy for stone disease is that, for most patients, the treatment will have to be observed for the subsequent 25–30 years if they are to avoid further stone episodes. The second problem, which applies particularly to the conservative management of stones, is motivating the patient and ensuring his or her compliance. Studies have shown that, unless patients have a further stone episode within a few months of commencing conservative treatment, then by 3–4 months they will have started to regress to their former "bad" dietary habits. By 9–12 weeks, the majority will have returned to their previous abnormal urinary biochemical pattern and a high risk of stones [14]. The only way to keep patients motivated is to review them regularly at the stone clinic, at least annually, and to discuss their course of management with them. A biennial URINESCREEN [9] will verify whether or not the patient is compliant and may be used to encourage him/her to adhere to the recommended form of prophylaxis. "Target diagrams" that provide the patient with a set of objectives to attain in order to score the "bull's eye" of optimum treatment have been devised [15]. These help to keep the patients focused on their particular method of treatment.

Drug treatment for idiopathic calcium stone disease

In the USA, it is often recommended that idiopathic calcium stone patients, especially the most recurrent cases, be treated with drugs geared to correct their particular urinary risk factors (Table 2). There is no doubt that, if patient compliance is good, these medications can reduce the recurrence rate of stone-formation [4, 10–12]. The two most commonly prescribed medications for calcium-containing stones are thiazide diuretics and tri-potassium citrate. Thiazides are particularly suitable for patients with a renal leak of calcium; potassium citrate is useful for most types of idiopathic stone-formers. Thiazides usually have to be accompanied by potassium supplements in order to prevent the development of hypokalaemia. One group

advocates the use of allopurinol [4] for the treatment of hyperuricosuric calcium stone-formers but the efficacy of this form of treatment is still debatable.

Other treatments that have been shown to be successful include supplements of phosphate (1–1.5 g P/day) or magnesium (500 mg Mg/day). Cellulose phosphate, once used as a calcium-binder to reduce the intestinal absorption and urinary excretion of calcium, is rarely prescribed now as it was found to increase urinary oxalate and the patients often ended up with a higher biochemical risk of forming stones than they had prior to treatment.

Efficacy of preventative therapy

The results of the above prophylactic measures have been encouraging. But this is possible only if the patient's motivation can be maintained. Data from the USA, where more attention is given to the medical management of patients with stones, show that recurrence rates can be cut drastically by the use of thiazides and potassium citrate, particularly when coupled with relevant advice on dietary and fluid intake [4, 11]. In a group of actively recurrent stone-formers treated this way, 83% were shown to be in remission after an average of 5.4 years and the remainder had recurrences at a rate of 1/7th of the pre-treatment rate [4].

The cost of these measures in the UK is minimal since the drugs concerned are relatively cheap to prescribe. At 1998 prices in the UK, the total projected cost of a course of thiazides for a patient for the next 30 years is estimated to be £175 plus a further £150 if potassium supplements are required. The total cost of potassium citrate medication is estimated at £250, phosphate supplements at £330 and allopurinol at £300 over the same period. Even if these measures succeed in reducing the recurrence of stones by only one episode per patient they will have more than paid their way, since 60% of episodes require urological intervention costing around £2,000 per patient episode. Current evidence from the USA suggests that the combination of conservative management with the above drug treatments will reduce the recurrence rate by considerably more than one episode per patient. At least two studies have shown substantial savings in the overall cost of managing stone patients by employing a screening and treatment approach to the problem rather than allowing the patients to continue without treatment and removing the subsequent recurrent stones by minimally-invasive procedures [4, 11]. In addition to the financial savings that would accrue to the Health Service by introducing a similar scheme in the UK, it would clearly be of considerable benefit to the patient not to have to suffer the discomfort and inconvenience of further stone episodes. It would also save the Exchequer considerable sums in unclaimed Sick Pay and industry a significant number of days otherwise lost from work.

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