Cost-Effectiveness of Primary Prevention Strategies for Nephrolithiasis

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Abbreviations and Acronyms

ER = emergency room

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Purpose: Stone disease is a highly prevalent condition associated with substantial cost and morbidity. We evaluated the cost-effectiveness of a primary prevention strategy.

Materials and Methods: A decision analysis model was constructed to compare the cost of ad hoc management of symptomatic stones vs the cost of primary prevention. A literature search was performed to determine the incidence of stone disease, the effectiveness of nonmedical prevention strategies and cost associated with stone management. One and 2-way sensitivity analyses were performed to determine conditions under which a strategy of primary prevention might be cost-effective.

Results: Assuming a 1% incidence of stones, a 50% risk reduction and a $100 cost per individual per year for primary prevention, the model was used to calculate the overall costs per individual per year without and with a primary prevention strategy of $46 and $123, respectively. One-way sensitivity analyses indicated that primary prevention was cost-effective if the incidence of stones exceeded 4.3% yearly or the cost of prevention was less than $23 per person yearly. Varying other factors (risk reduction, probability of requiring surgery, hours of lost work, emergency room cost) failed to reach cost equivalence under any circumstances or required unrealistic assumptions. Preventive strategies were more costly than no prevention unless the incidence of stone disease was at least 1%, the cost did not exceed $20 per person per year and the prevention strategy was at least 50% effective in preventing stones.

Conclusions: Primary prevention strategies for stone disease have not been sufficiently evaluated but can theoretically be cost-effective if the population has a sufficiently high incidence of stone disease and the strategy is of low cost and moderately effective.

Key Words: primary prevention, calculi, cost-benefit analysis

STONE disease is a highly prevalent condition, reportedly affecting 10% of men and 5% of women in the United States during a lifetime.[1,2] Incidence rates ranging from 0.1% to 0.3%[3–5] to as high as 1% in an employed population[6] or more than 2% in individuals living in a desert environment have been reported.[7] Because of the high prevalence of the condition among working age adults, stone disease is associated with substantial societal cost and individual patient morbidity. A recent study from the Urologic Diseases in America project estimated the total annual medical expenditure for urolithiasis in the United States at $2.1 billion in 2000, including $971 million for inpatient services, $607 million for physician office and hospital

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outpatient services, and $490 million for ER services.[8] However, the cost of stone disease encompasses more than just direct medical costs. Stone incidence peaks between the ages of 20 and 60 years, the time of highest work productivity. Insurance data from 25 large United States employers with more than 300,000 beneficiaries revealed that a worker filing a claim related to nephrolithiasis accounted for $3,500 ($6,532 vs $3,038) more in medical expenses than a matched worker without a diagnosis of a stone.[6]

A variety of factors such as gender, ethnicity, geography, fluid intake, diet, obesity, bowel disease, and other environmental and metabolic factors contribute to the risk of stone disease in any given individual or population.[9–11] Although patients with recurrent stones are often advised to modify fluid intake or diet and are occasionally prescribed medication to correct metabolic derangements, little effort has been aimed at primary prevention of kidney stones. In contrast, primary prevention strategies have been initiated for other highly prevalent conditions such as infectious diseases, cardiac disease and cancer. However, despite qualifying as a highly prevalent disease with significant morbidity, cost and impact on quality of life, stone disease has largely been ignored with regard to primary prevention efforts. A low cost intervention in populations with sufficient prevalence of stone disease could potentially prove to be cost-effective. For example, there is level 1 evidence that increased water intake can reduce the risk of stone recurrence by up to 50%.[12,13] Furthermore, dietary measures including limited intake of animal protein and salt combined with a normal calcium intake,[14] or an overall healthful diet like the Dietary Approaches to Stop Hypertension diet,[14] have been reported to be associated with a reduced risk of kidney stone formation.[15] Nevertheless, the initiation of even simple dietary or fluid measures is associated with cost, including the cost of an educational campaign, the cost of increased water consumption, particularly if sanitized water is not readily available, and the cost of increased fresh fruit and vegetable consumption. In this study we explore the cost-effectiveness of primary prevention of kidney stones.

MATERIALS AND METHODS

Decision Tree Model

A decision analysis model (TreeAge Pro™ Healthcare 2004) was constructed to estimate the cost of primary prevention of stones in an at risk but general population. The decision tree compared the cost of ad hoc management of symptomatic stones in a control population vs the cost of a primary prevention strategy to reduce the risk of stone events. For the model the cost of ad hoc symptomatic stone management included cost accrual for an ER visit for an acute stone event, medical expulsive therapy, surgical intervention for stones that fail to pass spontaneously, and lost wages related to the ER visit and surgery.

For the purpose of the model the baseline incidence of stones was estimated at 1% yearly.[6] While this incidence may be on the high end of published estimates, the model will calculate the cost over a 10-fold range of incidences. We assumed that all diagnosed stones are symptomatic because in the general population a stone that is not symptomatic is unlikely to be diagnosed in the absence of unrelated radiographic imaging studies. We further assumed that 55% of symptomatic patients require surgical intervention annually, based on combined results of published reports evaluating the natural history of untreated, asymptomatic calyceal stones.[16–19] Among patients who require surgical intervention, half undergo shock wave lithotripsy and half are treated with ureteroscopy according to recent claims based data.[8] The range of costs for surgical treatment and ER visits was based on a previously published comprehensive international economic survey involving 9 countries.[20] The risk reduction associated with primary prevention was estimated at 50% based on evidence from a randomized, controlled trial showing that incorporating the simple measure of increasing water intake sufficient to produce a urine volume of at least 2 l daily reduced the risk of recurrent stone formation by up to 50%.[12,13]

Outcomes

The costs of managing de novo symptomatic stones with or in the absence of a prevention program were calculated. A series of 1-way sensitivity analyses were performed which evaluated the effect of various combinations of individual probabilities and costs by varying 1 parameter while holding the others fixed. Two-way and 3-way sensitivity analyses were performed to evaluate the impact of varying different parameters simultaneously.

RESULTS

Applying the model based on a 1% incidence of stone disease and the costs outlined in table 1 yielded an overall cost per individual per year, without and with a primary prevention strategy, of $46 and $123, respectively, taking into account the cost of primary prevention and the cost of failure (developing a symptomatic stone that might require surgery).[3,6,13,21–24] One-way sensitivity analyses were used to determine threshold values at which no prevention and prevention have equivalent costs (table 2). Arbitrarily, if a prevention strategy cost $100 yearly (approximately 30 cents daily), then the incidence of a symptomatic stone event had to be 4.3% yearly to break even with the cost of prevention. However, if the incidence of a symptomatic stone event was only 1% yearly, then the cost of prevention would have to be decreased to $23 yearly (approximately 6 cents daily) to reach cost equivalence by compensating for the lower frequency of the event. Varying other individual factors (risk reduction,