

# Economic impact of urinary stones

Elias S. Hyams<sup>1</sup>, Brian R. Matlaga<sup>2</sup>

<sup>1</sup>Division of Urology, Dartmouth-Hitchcock Medical Center, Lebanon, NH, USA; <sup>2</sup>Brady Urological Institute, Johns Hopkins Hospital, Baltimore, MD, USA

*Correspondence to:* Brian R. Matlaga, MD, MPH. Associate Professor of Urology, Brady Urological Institute, Johns Hopkins Hospital, 600 N. Wolfe Street, Park 221, Baltimore, MD 21287, USA. Email: bmatlag1@jhmi.edu.

**Abstract:** Kidney stones have been rising in prevalence in the United States and worldwide, and represent a significant cost burden. Cost effectiveness research in this area may enable improvements in treatment efficiency that can benefit patients, providers and the healthcare system. There has been limited research in the cost effectiveness of surgical interventions for stone disease, despite the diverse treatment approaches that are available. Medical expulsive therapy (MET) has been shown to improve rates of stone passage for ureteral stones, and there is evidence that this practice should be liberalized from the standpoint of both clinical and cost effectiveness. While conservative treatment following a primary stone event appears to be cost effective, the economic impact of medical therapy for recurrent stone formers requires clarification despite its clinical efficacy. Future study regarding the cost effectiveness of prevention and interventions for stone disease are likely to improve both the quality and efficiency of care.

**Keywords:** Kidney stones; nephrolithiasis; cost; health care economics

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## Introduction

The prevalence of kidney stones has steadily risen in recent decades, with >8% of the United States population presently being affected (1). A significant economic burden is associated with kidney stones, with annual estimates exceeding \$5 billion (2,3). This economic toll includes both direct treatment costs, and the indirect costs associated with lost worker productivity. Unfortunately, there has been limited cost effectiveness research in the area of kidney stone management; this research requires advancement, given the panoply of surgical and medical treatments of stone disease with uncertainty regarding comparative effectiveness incorporating short and long term endpoints. In this paper, we present data regarding the economic impact of kidney stone disease, and review the cost effectiveness of surgical and medical interventions based on existing literature.

## Clinical burden of kidney stones

Nephrolithiasis is common and rising in prevalence.

Lifetime risk in the United States exceeds 12% in men and 6% in women (4). Also, stone formers are notorious recidivists, as up to 50% of patients develop recurrence after their initial event (5). Based on the acute nature of presentation, kidney stones generate a large volume of emergency department visits and hospital admissions. The Healthcare Cost and Utilization Project reported that, in 2009, there were 1.3 million ED visits for kidney stones, with >3,600 ED visits for stones every day (6). The upward trend is significant, with ED visits increasing 20% between 2005 and 2009, and rates of hospitalization increasing 14% in the same period. Approximately 20% of ED visits for stones result in hospitalization, with most patients being treated as outpatients. This clinical demand is associated with a substantial economic burden as discussed below.

## Economic burden of kidney stones

Unlike many chronic diseases, kidney stones primarily affect working-age adults between ages 20 and 60 (4). Thus the economic burden of kidney stones includes both direct and

indirect costs, the latter including decreased or lost work productivity. In 2005, the Urological Disease in America Project analyzed direct and indirect costs of stone disease using medical and pharmacy claims of 25 large United States employers covering >300,000 beneficiaries aged 18-64 for calendar year 2000 (2). Notably, these authors utilized actual reimbursement data to estimate the cost of services, and linked services to absentee data for more precise estimations of lost productivity. These authors reported a significant increase in mean annual expenditures for those with a claim for nephrolithiasis (as primary diagnosis) versus similar adults without the condition (\$6,532 *vs.* \$3,038). They estimated that, for the >1.3 million people in the labor force between ages 18 and 64, total direct costs of stones constituted ~\$4.5 billion among employed individuals. Regarding the indirect costs of stone disease, Saigal and colleagues found that 30% of patients missed work because of their condition, with a mean work loss of 19 hours per year (2). For those requiring inpatient hospitalizations, mean work loss was 47.9 hours, while ambulatory care visits necessitated lost work of 5.1 hours. The authors estimated that treatment of stones was associated with 3.1 million lost workdays per year among the privately insured, concluding that the indirect cost of stones approximated \$775 million per year.

There are additional prior studies of the economic burden of stone disease. Pearle and colleagues evaluated direct costs in a 2004 study (3). Using a number of national datasets, they found that annual expenditures on stone disease comprised \$2.1 billion in 2000, including \$971 million for inpatient care, \$607 million of physician office and hospital outpatient care, and \$490 million for ED services. In a study from 1995, Clark and colleagues reported that the direct and indirect costs approximated \$1.83 billion (7). This figure is significantly less than the estimate by Saigal and colleagues because of the growth in medical spending between studies, and use of different methodologies, e.g., use of expert opinion *vs.* labor data for estimates of lost work days, use of charge *vs.* actual reimbursement data, etc. (2).

Data suggest that the economic burden of stones is shifting from the inpatient to outpatient setting. Outpatient services including physician office visits and the ED comprised an increasing proportion of expenditures on stone disease, from 43% in 1994 to 53% in 2000 (3). More updated data are not presently available, however this trend is likely to continue as payers and providers seek lower cost settings for treatment of stones.

### **Economics of medical expulsive therapy (MET)**

MET has become a standard adjunctive treatment in patients with ureteral stones undergoing conservative treatment (8). Data convincingly demonstrate an improvement in stone passage rates (9). However, the cost of MET is complex, including cost of follow-up care if symptoms persist (e.g., ED presentations, subsequent surgical treatment) as well as direct medication costs. Indeed, Hollingsworth and colleagues recently demonstrated that MET is associated with more ED visits compared with early endoscopic treatment, though overall payments were significantly less with MET *vs.* early surgery (10). Other models have shown that MET is cost effective even making “worst case” assumptions such as low cost of definitive treatment, small benefit of MET, and low rate of spontaneous passage (11). While MET may be cost effective for patients with mid- to proximal ureteral stones, based on incremental improvements in spontaneous passage rates (12), clinical judgment is critical to decide when early endoscopic treatment is most clinically and cost effective. Ultimately, based on high quality evidence that stone passage rates are enhanced, savings are likely to be achieved with more widespread use of MET for ureteral stones.

### **Economics of surgery for kidney stones**

There are limited studies regarding the cost-effectiveness of surgical treatment options for stone disease. Such data would be welcome given the manifold treatment options for stones of various sizes in various positions in the urinary tract [i.e., ureteroscopy (URS), shock wave lithotripsy (SWL), and percutaneous nephrolithotomy (PCNL)]. For instance, while PCNL is preferred for large renal stones, intermediate size renal stones can be treated with single or multi-stage URS; also clinical guidelines support use of either SWL or URS for most ureteral or smaller renal stones (13,14). Investigation in this area is limited by inadequacies in clinical effectiveness research for treatment of stones, such as heterogeneity of outcome measures in the literature (15), and lack of long term follow up. In this section, we present salient findings from the literature regarding cost effectiveness in the surgical management of stone disease.

### ***Shock wave lithotripsy (SWL)***

SWL is historically the most common treatment approach for small renal and ureteral stones, though practice patterns

are shifting toward endoscopy (16,17). There are limited studies on the cost of SWL, however multiple studies provide data on optimizing outcomes, such as reserving treatment for smaller stone burdens, stones with lower Hounsfield units (<1,000), patients with shorter skin-to-stone distance (<10 cm), and in the case of LP stones, favorable lower pole anatomy including infundibulopelvic angle and length (18,19). From an efficiency standpoint, studies have demonstrated that slowing SWL rate significantly improves fragmentation and reduces the cost of SWL by 50% by reducing the need for auxiliary procedures (20). These types of considerations in the practice of SWL are likely to improve the cost effectiveness of this treatment modality.

### *Ureteroscopy (URS)*

Literature on the cost effectiveness of URS *vs.* SWL has been limited; however data suggest a clinical advantage of URS for distal ureteral stones (21). Unfortunately, there is a lack of rigorous evidence to meaningfully compare outcomes for stones elsewhere in the upper urinary tract. Despite limitations of the evidence, a recent systematic review by Matlaga and colleagues found that URS does appear to be cost effective compared with SWL, with superior stone-free rates and overall cost (22). Clinical advantages of URS are intuitive, as flexible URS provides access to the entire collecting system, and direct visualization and removal of stones. However, cost of URS is complex and requires accounting of both short-term (e.g., operating room time, supplies) and long-term costs (e.g., future stone events and/or treatment).

An important cost variable for flexible URS is maintenance of instrumentation. Studies have demonstrated that, after one repair, the risk of requiring additional maintenance increases significantly (23). As such, it may be cost effective to replace a damaged scope rather than repair it repeatedly. Damage to scopes may occur regarding optics or within the sheath. There are techniques to minimize damage to ureteroscopes, such as minimizing severe flexion (e.g., by displacing lower pole stones to more accessible calyces), advancing laser fibers only when the scope is straightened, not firing the laser within the channel, and using a ureteral access sheath for treatment of larger burdens (24). Care during cleaning of ureteroscopes, including having urology staff involved in this process, may reduce processing-related damages and save costs compared with central processing (25).

An area of investigation has been the cost effectiveness

of pre-stenting patients undergoing URS. Chu and colleagues retrospectively studied 104 patients with upper tract (primarily ureteral) stones with a wide range of stone sizes (0.3-4 cm; median 1 cm) (26). The authors found that pre-stenting significantly reduced the total costs (direct and indirect) of treatment for patients with stones >1 cm, even when assuming a cost of pre-stenting up to 6.2 times the current cost. A limitation of this study was use of reimbursement data rather than actual cost data. Nonetheless, there appeared to be a cost advantage for pre-stenting patients with larger stone burdens undergoing URS. Additional research is needed to better delineate the cost effectiveness of endoscopic treatments for larger stone burdens, in terms of timing of stent placement, the use of staged procedures, and comparison with alternative approaches such as percutaneous surgery.

### *Percutaneous nephrolithotomy (PCNL)*

PCNL is the standard of care for treatment of large (>2 cm) and/or complex renal calculi based on superior stone clearance (27,28). There is evidence that PCNL is cost as well as clinically effective, based on reduction of the need for follow-up surgery, despite higher short term costs (e.g., inpatient hospitalization, disposable supplies, etc.) (20,29). Nonetheless, there has been effort in the literature to improve the cost effectiveness of PCNL. A driver of higher cost of PCNL has been shown to be second look flexible nephroscopy (SLFN), which is influenced by primary stone size (30). A recent study demonstrated that SLFN is cost effective for residual fragments >4 mm but not ≤4 mm, based on risk of future stone events and interventions (31). This provides practicable data for practitioners in deciding whether to pursue these small residual fragments.

Increased surgeon experience is also thought to impact cost outcomes of PCNL. Studies have demonstrated that increased experience is associated with decreased operative time, lower 30 day mortality, and lower rates of ICU hospitalization which are associated with cost (32-34). Experience of the surgeon as well as the operating room staff, based on the need for technical support and “trouble shooting” equipment during these cases, are likely to enhance OR efficiency. It may be that regionalization for PCNL would be a cost effective approach, though this requires additional study.

Finally, there has been study of the cost effectiveness of bilateral *vs.* staged unilateral PCNL for patients with bilateral large stone burdens. Bagrodia and colleagues

reported that simultaneous bilateral PCNL decreased overall operative room time, length of stay and cost, thus was advantageous to both patients and third party payers (35). Notably, though, physician reimbursement with synchronous bilateral surgery was significantly less than staged procedures, providing a disincentive for the approach. This study underscores the importance of aligning financial incentives between providers and systems when striving to reduce costs.

## Economics of kidney stone prevention

### Primary prevention

The data are limited regarding the cost effectiveness of primary prevention of stone disease. Primary prevention may be cost effective in specific populations, e.g., based on geography (e.g., warmer climates), familial or medical factors, or changes in environment (e.g., military deployment) (12,36). Decision analysis models have demonstrated that primary prevention can be cost effective provided the following assumptions hold true: the incidence of disease is at least 1%, cost does not exceed \$20/person/year, and the strategy is at least 50% effective at stone prevention (37). It is speculated that low cost interventions such as education regarding water consumption may be cost effective, but this requires further study (36,37).

### Secondary prevention

First time stone formers typically undergo dietary manipulations to modulate their risk, including increased hydration, reducing salt and animal protein intake, reducing oxalate intake, and increasing citrate intake (38). Dietary manipulations have been shown to reduce stone recurrent in these patients (39,40). Recurrent stone formers generally undergo a metabolic evaluation and are considered for medical therapy to reduce their risk (41-43). While data support use of medical therapy in these patients, there are disadvantages of this approach, such as side effects, inconvenience and medication cost that can impact patient compliance (12,44). Studies from the 1990s argued that selective medical therapy lowers costs (45,46), however these studies did not account for the benefits of dietary therapy alone, the costs of metabolic evaluation, and the fact that not all recurrent stones require treatment. Nonetheless, more recent studies have demonstrated that medical therapy in known stone formers can be cost effective (2). Lotan and

colleagues published a decision-analysis model regarding the cost effectiveness of conservative therapy *vs.* medical therapy in first-time *vs.* recurrent stone formers (41). Medical therapy was not cost effective in first time stone formers. In recurrent stone formers, however, drug treatment was more costly but decreased recurrence by 60-86%, thus became cost effective. Lotan and colleagues also evaluated the cost effectiveness of medical therapy in various international settings (47). Interestingly, the cost effectiveness of medical therapy varied from country depending on cost of treatment and cost of surgery. In most countries, empiric and directed medical therapy were more effective at controlling stone disease, but were not cost effective because of the low likelihood of surgical intervention and the relatively low cost of surgery. In the United Kingdom, however, medication costs were sufficiently low that empiric therapy became cost effectiveness. To optimize use of medical therapy, then, requires methods of further reducing medication costs, improving compliance, identifying the patients most likely to benefit, and improving the effectiveness of treatment itself (12).

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## Footnote

*Conflicts of Interest:* The authors have no conflicts of interest to declare.

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