AUA
VOLUME 42 UPDATE SERIES LESSON 15
2023

# Cost Control in Stone Management

**Learning Objective:** At the conclusion of this continuing medical education activity, the participant will be able to compare the cost of ureteroscopy, percutaneous nephrolithotomy, and shock wave lithotripsy. The participant will also be able to apply methods to control the costs of the procedures performed to treat stones.

This AUA Update aligns with the American Board of Urology Module on Calculus, Laparoscopy-Robotics and Upper Tract Obstruction. Additional information on this topic can be found in the AUA Core Curriculum section on Urolithiasis.

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**KEY WORDS:** stones, costs, ureteroscopy, percutaneous nephrolithotomy, shock wave lithotripsy

## INTRODUCTION

The cost of health care in the United States has been an increasingly important issue during the past several decades. The U.S. now spends 19.7% of its gross domestic product on health care. The increasing percentage of gross domestic product consumed by health care has been a cause for alarm, but one can reasonably ask if a wealthy country chooses to spend its disposable income on health care, why does such spending represent a problem? The concern should not be that Americans are choosing to spend a larger proportion of their income on health care, but rather that the government is borrowing the money to fund this health care.

Economies can bear substantial debt without dire economic consequences, but a limit exists as to how high debt can rise without significant economic harm. At some debt level, the financial markets will reach the conclusion that the U.S. cannot meet its debt obligations. Concern that the U.S. government cannot repay its debt will lead to a sovereign debt crisis. A sovereign debt crisis results in a lower standard of living due to slower economic growth and stagnant or even negative wage growth. A debt spiral occurs when creditors abruptly pull funds from the U.S., resulting in a rapid destruction of the economy and a prolonged lower standard of living.

**Physicians have direct or indirect control of more than 80% of health care spending.[1] Surgical care accounts for 40% of all U.S. health care spending,[2] and surgeons can therefore play a major role in decreasing health care costs.** As physician reimbursement is currently structured, most physicians are neither aware of nor greatly concerned about the financial effects of their choices. Physician leadership is required, and individual physicians can lead the way in controlling costs by focusing on small changes in their daily activities.

Stone disease continues to increase in prevalence, and the cost of treating stones is rising with estimates that more than $5 billion is now being spent annually to treat stone disease in the U.S.[3] Urologists have several options to treat stones, and occasionally the treatment choice is obvious. However, in many cases, physicians have wide discretion regarding how stones are treated. **Treatment of stone disease is resource intensive and represents a high-yield target to decrease expenditures.** This Update compares the cost of the various stone treatments, reviews factors which control these costs, and suggests methods for urologists to decrease the costs of the stone treatment they provide.

Cost comparisons between percutaneous nephrolithotomy (PCNL), ureteroscopy (URS), and shock wave lithotripsy (SWL) are difficult given the tremendous heterogeneity of stone and patient factors, the different equipment available to treat stones, and the range of surgeon experience. The most cost-effective stone treatment is difficult to demonstrate definitively. Cost-effectiveness implies a comparison of the cost of equal outcomes. "Cost-effectiveness" studies in medicine have limited value as outcomes after different treatments are rarely equivalent. Comparisons between stone treatment are further complicated by the wide variety of unique factors associated with each stone, including stone burden, stone consistency, stone location, patient anatomy, intrarenal anatomy, surgeon training and experience, and the equipment available to the surgeon.

When discussing health care costs, the term "costs" must be defined. Charges, reimbursement, and hospital calculated costs have all been used to represent costs. Hospital calculated costs can be additionally stratified by direct variable costs, indirect variable costs, direct fixed costs, and indirect fixed costs. Direct fixed costs do not change over time and include fixed labor costs, equipment acquisition costs, and administrative expenses. Indirect fixed costs include building costs, utilities, information technology, insurance, billing, medical records, and security. Direct variable costs include variable labor costs and patient supplies. Urologists have great control over direct variable costs and some control over direct fixed costs as they should have input over the capital equipment used in their cystoscopy suites. Societal costs such as cost of patient and caregiver time, transportation costs, and effects on future productivity are extremely difficult to quantitate and are not addressed in this Update.

## SWL AND URS

The introduction of SWL revolutionized the management of renal calculi.[4] Within 5 years, the number of patients treated with SWL had increased 5-fold, and the number of patients requiring open surgery had fallen by 90%.[5] While the historical cost-effectiveness comparisons were to open surgery and PCNL, the contemporary alternative to SWL is URS.[6,7] Rigid URS became popular in the late 1980s and flexible URS in the 1990s. The technology of flexible ureteroscopes has continued to improve, and these improvements have expanded their use. When comparing URS to SWL, common themes emerge.

**First, per-procedure costs of SWL are similar to per-procedure costs of flexible URS.** Cone et al found that per-procedure, charge-based costs were $3,167 for SWL and $4,470 for URS.[8,9] Hollingsworth et al used claims data and found that payments for SWL and URS were $943 and $634, respectively, and payments in a hospital were $4,754 and $2,129.[10] Patel et al used cost-to-charge ratios and found the per-patient cost at 3 months to be $6,239 for initial SWL and $5,319 for URS.[11] Two groups from the UK found the average cost per treatment was lower for SWL than for URS (£426 vs £2,602 and £750 vs £1,261).[12,13]

The U.S. studies assessing the cost-effectiveness of SWL favor URS. **A decision analysis model evaluating renal calculi <1.5 cm found that SWL was not cost-effective without a single procedure stone-free rate greater than 65%-67% or a URS single procedure stone-free rate less than 72%-84% despite costing 29% less than URS.[8]** A similar decision analysis model evaluated ureteral calculi <1.5 cm and determined that SWL was not cost-effective without a single procedure stone-free rate greater than 60%-64% or a URS single procedure stone-free rate less than 57%-76%.[9] A Markov model

**ABBREVIATIONS:** operating room (OR), percutaneous nephrolithotomy (PCNL), shock wave lithotripsy (SWL), ureteroscopy (URS)

simulating treatment options for 1- to 2-cm renal stones found that while SWL is associated with the lowest costs for primary intervention, the overall cost was dramatically increased by the need for re-treatment and secondary procedures.[14]

**With similar costs between SWL and URS, maximizing SWL cost-effectiveness requires maximizing single procedure stone-free rates, avoiding unnecessary costs, preventing complications, and limiting the number of secondary and tertiary procedures.** Adjuvant treatments including α-blockers and percussion, diuresis, and inversion may help patients pass residual fragments and improve stone-free rates.[15] Experienced radiological technologists use less fluoroscopy with superior stone-free rates.[16] **Routine pre-stenting increases costs without improving stone-free rates or decreasing the risk of Steinstrasse and is not recommended by the AUA.**[6] The majority of residual fragments ≤4 mm after SWL clear within 8 weeks,[17] and among those that remain at 3 months, only 31% require reintervention.[18]

## PCNL

PCNL is a common surgical approach for large upper tract stones. The definition of large stones varies but is generally defined as stones ≥2.0 cm.[19] PCNL results in increased stone clearance rates compared to URS for large, proximal stones.[20,21] The cost is impacted by the number of additional procedures required, the length of hospital stay, and the complication rate. PCNL requires fewer additional procedures when compared to URS for stones greater than 1 cm.[20] Although PCNLs have higher complication rates and longer hospital stays, the cost of additional procedures significantly increases the overall cost of URS compared to PCNL.[20,22] Erdoğan et al reported the mean cost per patient with stones 1-3 cm being treated with URS was $749, but only $320 for those undergoing PCNL.[21]

The timing and method of renal access affect the cost of PCNL. In the U.S., interventional radiologists obtain access for the majority of PCNLs.[23] **When access is obtained by urologists, there are lower complication rates, lower rates of prolonged hospitalization, and higher stone-free rates.**[22,24] The median cost for PCNLs when access was obtained by a urologist was found to be lower ($10,173) when compared to access obtained by an interventional radiologist ($11,287).[24] If access is obtained by a urologist, the imaging modality utilized to gain access can also affect the overall cost of PCNL. When comparing the cost of PCNL using fluoroscopy or ultrasound, Hudnall et al reported the mean total cost per case was 30% less for ultrasound-guided access.[25] Using Amplatz serial dilators and single-step balloon dilators is associated with higher costs when compared to metal serial or metal single-step dilators.[26] However, single-step balloon dilators are associated with shorter procedure length.[27]

**Leaving a ureteral stent or nephrostomy tube or performing tubeless PCNL will also affect the overall cost of the procedure.** Performing completely tubeless PCNL has been shown to be less costly when compared to leaving a ureteral stent or nephrostomy tube, with mean operating costs being $2,380 and $2,845, respectively.[28] However, tubeless PCNL would generally only be performed in uncomplicated, straightforward procedures, and the cost should be lower in these cases.

Urologists have been performing PCNLs through smaller access tracts with the goal of decreasing the morbidity of the procedure. Mini-PCNLs are performed through 14F to 20F tracts, ultra-mini–PCNLs are performed through 11F to 13F tracts, and micro-PCNLs are performed through tracts as small as 4.8F.[29] Though these smaller access tracts are associated with fewer complications, the capital equipment may be more costly, and they are also associated with a decreased stone clearance rate.[29,30] Ultra-mini–PCNL was found to have decreased cost for disposables and endoscopes for stones 1-2 cm when compared with flexible URS.[6]

**The effect on costs of how access is obtained, how the tract is dilated, and whether to leave a nephrostomy tube or stent are illustrative of how treatment decisions during the procedure have a significant effect on costs not only for PCNL, but also for URS.** Surgeon skill, experience, and comfort impact both efficacy and cost. For example, although PCNLs have been shown in ideal situations to be the less costly approach for treatment of large renal stones, urologists more comfortable with URS may be able to safely and quickly treat large stones with fewer complications and additional procedures, and therefore with lower cost, with URS.

## COST COMPARISONS

Cost comparisons between SWL and PCNL (Table 1), SWL and URS (Table 2), and URS and PCNL (Table 3) have been published. These studies demonstrate 3 important takeaways. First, the wide range of costs for the same procedures in these studies illustrates the method of cost determination will affect the outcomes. Second, the specific stone size and location in

**Table 1**. Cost Comparison Between Shock Wave Lithotripsy and Percutaneous Nephrolithotomy

| | SWL | PCNL |
|---|---|---|
| May and Chandhoke[41] | $12,638 | $40,965 |
| Schulz et al[42] | $5,983 | $7,837 |
| Wymer et al[14] | $10,916 | $10,290 |
| Chan et al[13] | £2,651 | £750 |

Abbreviations: PCNL, percutaneous nephrolithotomy; SWL, shock wave lithotripsy.

**Table 2**. Cost Comparison Between Ureteroscopy and Shock Wave Lithotripsy

| | URS | SWL |
|---|---|---|
| Koo et al[43] | €2,602 | €426 |
| Pearle et al[44] | $6,088 | $7,343 |
| Parker et al[45] | $9,600 | $15,900 |
| Wu et al[46] | $953 | $1,401 |
| Wu et al[47] | $1,054 | $1,431 |
| Lee et al[48] | $2,154 | $1,637 |
| Salem[49] | $1,140 | $1,300 |
| Cone et al[8] | $4,470 | $3,167 |
| Chan et al[13] | £1,261 | £750 |
| Wymer et al[14] | $5,930 | $10,916 |
| Schulz et al[42] | $5,553 | $5,983 |

Abbreviations: SWL, shock wave lithotripsy; URS, ureteroscopy.

**Table 3**. Cost Comparison Between Percutaneous Nephrolithotomy and Ureteroscopy

| | PCNL | URS |
|---|---|---|
| Wymer et al[14] | $10,290 | $5,930 |
| Schulz et al[42] | $7,837 | $5,553 |
| Chan et al[13] | £2,651 | £1,261 |

Abbreviations: PCNL, percutaneous nephrolithotomy; URS, ureteroscopy.

these studies emphasize the lack of generalizability of these results. Third, the studies' outcomes are not in one direction, indicating that how costs are calculated, how procedures are performed, and how models are constructed significantly influence the outcomes. **These studies demonstrate that the most cost-effective method to treat stones is not settled and the most cost-effective method to treat a particular stone depends on the unique factors of the stone, the patient, and the surgeon. Additionally, the cost-effectiveness of stone treatment is a moving target. Changes in costs, technological changes, and evolving surgical skills will change the cost-effectiveness of stone treatments.**

## CAPITAL EQUIPMENT

Capital equipment represents a significant portion of the cost of stone treatment. Technological innovation in stone treatment is constant, and the pressure to have the latest equipment is ever present. Every hospital cannot have every available piece of equipment, nor can they constantly update their equipment as technology evolves. New equipment is usually not replacing equipment that is obsolete, and therefore the new equipment is not essential to the delivery of care but rather allows for continuation of a current revenue stream. The cost of capital acquisition cannot usually be passed on to the payer; and the newer, more expensive equipment does not lead to increased reimbursements. Since the new equipment increases the cost per case, the profit margin for the procedure will decrease. The important metric for new technology is the marginal clinical benefit and the key question, is the marginal benefit worth the cost? Unfortunately, these questions are very difficult to answer as large information gaps exist on price and performance of capital equipment.

Urologists are largely unaware of the capital costs of the equipment they use. They may know the purchase price of the equipment but do not have knowledge of the much more important cost per case. The primary factor in determining the cost per case is the number of uses, which depends on the volume of procedures performed and the lifespan of the equipment. The cost per case will also be determined by how the equipment is amortized and depreciated, associated maintenance and service costs, and debt service. The marginal clinical benefit of newer equipment is very difficult if not impossible to accurately calculate. For example, a wide variety of lasers are available with a range of both energy and price. Is a $250,000 laser that can provide 100 W of power worth the price when a 35-W laser can be purchased for $40,000 and can treat most stones? A small decrease in operative time achieved by a higher-powered laser is unlikely to significantly decrease operating room (OR) costs. However, if a high-powered laser can be used to dust a stone and avoid the need for use of a stone basket, do those savings allow a higher-powered laser to pay for itself over time? Will the ability to confidently dust a stone eliminate the need for and cost of a ureteral access sheath? What is the marginal clinical benefit of a digital ureteroscope compared to a fiberoptic ureteroscope, and is the increased cost worth that benefit? Are the increased repair rate of digital ureteroscopes and the resulting increase in cost per case worth the marginal clinical benefit? Does improved video equipment improve clinical outcomes, and would the improved clinical outcomes be worth the increased cost? **These questions are only a few of the many decisions that urologists must make as they strive to treat stones in the most clinically and cost-effective manner.** These questions are very difficult to answer in a scientific manner and are left to individual physicians and hospital systems to answer for their unique situations.

Urologists are taught from their first day of training that OR time is expensive, and every minute of OR time saved results in significant cost savings. This widely held belief does not hold up to accounting scrutiny. **Most OR costs are fixed costs and are not dependent on OR time.** The only potential marginal costs in the calculation of OR time costs are staff costs. The use of higher-cost technology that may decrease OR times will not result in significant cost savings and cannot be used to justify the purchase of higher-cost capital equipment. The exception would be if OR times are decreased sufficiently to allow for an additional case to be performed during that OR block time. In that scenario, because of the fixed costs of the OR, virtually the entire reimbursement for the additional case will be profit. Similarly, inpatient costs are largely fixed costs. **Decreasing the length of stay or avoiding inpatient stays altogether will decrease charges but will only minimally decrease costs as only a very small portion of inpatient costs are direct variable costs.**

## DISPOSABLE URETEROSCOPES VS REUSABLE URETEROSCOPES

Disposable ureteroscopes are available,[31] and one of the proposed benefits of these scopes is cost savings since the maintenance of reusable scopes is costly.[32] As the technology of flexible ureteroscopes has improved, their durability has decreased. By eliminating repair costs, disposable scopes may decrease the costs of treating stones. Several studies have compared the costs of disposable and reusable scopes. **These studies have concluded the cost-effectiveness of disposable scopes depends on the number of procedures performed.** Mager et al found that if a service performs greater than 99 URS procedures per year, reusable scopes are less costly than disposable scopes.[33]

**Whether disposable scopes will decrease costs will depend on the cost of disposable scopes and the durability, repair costs, and acquisition costs of reusable scopes.** The maintenance costs of reusable scopes can be decreased. Surgeon education can increase the time until scope injury as well as decrease the frequency of scope damage.[34] Education of OR staff and central sterile personnel can also decrease the frequency of scope repair.[35] The use of third-party vendors to repair ureteroscopes rather than the original equipment manufacturers can also significantly decrease costs. **By decreasing the costs of reusable scope repairs, the calculus of the cost**

**benefit of disposable scopes will change significantly.** Until these factors are studied more completely, the role of disposable scopes in the treatment of stones cannot be definitively determined.

An additional method to lower the cost of URS by utilizing disposable scopes is to use these scopes when performing cases which have a higher risk of scope damage. Cases which have been proposed to have a higher risk of scope injury include treatment of lower pole stones and large stones[36]; however, no data exist to confirm this assertion. Additionally, even if disposable scopes are to be used only in these cases, common sense and experience inform us this limitation is difficult to enforce and will probably not hold. Since disposable scopes are onetime use, the optics and maneuverability do not decline over time as is the case with reusable scopes, and therefore surgeons may prefer their use. Once disposable scopes are available, surgeons will likely use these scopes in cases other than lower pole and larger stones.

## COSTS OF DISPOSABLE SUPPLIES

A significant cost of treating stones is the disposable equipment utilized during these procedures. These costs are variable, and for most insurance carriers they are not reimbursed on an itemized basis. Commonly used disposable equipment in stone cases has a wide range of costs among manufacturers (Table 4). Despite these variations in cost, no data exist to demonstrate a difference in the outcome within these device categories. **Surgeons have very limited knowledge of the cost of the equipment they use since surgeons' compensation is not affected by the cost of disposable equipment used during the procedures they perform.**[37]

**Since disposable costs are generally variable costs, every dollar not spent on disposable supplies represents a full dollar saved.** Therefore, these expenditures are fertile ground to realize cost savings. The cost of stone procedures is largely fixed in terms of OR time, capital equipment, staffing costs, and anesthesia costs. **However, the surgeon can significantly affect costs by economizing on disposable supplies both by limiting their use and by selecting lower-cost items.** By not having OR staff automatically open disposable equipment, using this equipment only when necessary, using lower-cost equipment when possible, and most importantly by making surgeons aware of the costs of the equipment they are using, the costs of stone procedures can be significantly reduced.

## HOW CAN UROLOGISTS CONTROL COSTS?

The aging population, technological innovation, defensive medicine, and the lack of a true market in the health care sector are the primary reasons given for the high cost of health care in the U.S., and these factors certainly do play a role. The fact that the cost of health care in the U.S. is significantly higher per capita when compared to other developed countries is presumed to be evidence the U.S. overspends on health care. However, health care costs are largely driven by labor costs, and labor costs in this country are significantly higher when compared to other countries. When productivity increases, wages increase as laborers produce more per dollar paid in wages. In contrast to other sectors, productivity in health care has not increased. Since the productivity of the labor for which health care is competing has increased, the health care sector must increase the wages of its labor to remain competitive. In this way, health care labor costs increase without a corresponding increase in productivity, decreasing the value of the care provided. In our view, labor costs are the primary reason for the high and increasing costs of health care in this country.

The question, then, is how to increase productivity in health care. Total factor productivity describes the ability to increase output utilizing the same inputs. How can urologists increase their productivity using the same inputs? The information revolution has led to significant increases in productivity in many areas of the economy, but it is not clear health care has benefited from the information revolution in terms of productivity.

Surgeons have historically been rationally ignorant of the costs they generate. Many studies have demonstrated that simply providing cost information to surgeons will result in surgeons decreasing the cost of the services they provide.[38-40] **Hospital systems have developed sophisticated programs to calculate the cost of the care provided. Hospitals should provide these cost data to surgeons for each case the surgeon performs. Providing this information to surgeons is a relatively simple method to decrease costs.** These reports can be used to incentivize physicians to increase the value of the care they provide by decreasing costs while maintaining outcomes. Hospital systems can also provide the profit margin of each case to the surgeon. Profits per case are by no means an important goal of surgeons, but without sustainable margins a health care system will not survive. This information will help surgeons decide if more expensive technology is worth the costs and provide surgeons a reason to more closely consider the marginal benefit of newer technology. These approaches are methods for hospitals to use their sophisticated information and accounting systems to improve productivity and decrease costs, allowing the information revolution to increase the value provided in health care.

**Table 4**. Range of Costs of Disposable Equipment

| Equipment | Cost range |
|---|---|
| Ureteral stents | $50-$90 |
| Guide wires | $40-$70 |
| Stone baskets | $150-$400 |
| Ureteral access sheaths | $100-$200 |
| Dual lumen catheters | $30-$70 |
| Laser fibers | $200-$1,000 |

## CONCLUSIONS

Many studies have been published comparing the costs and cost-effectiveness of URS, SWL, and PCNL. Significant methodological differences exist among these studies that make assessing and analyzing cost-effectiveness difficult, and these studies do not provide much guidance for physicians. These methodological differences do not allow for definitive determination of the most cost-effective treatment for a specific clinical situation. The most cost-effective stone treatment for a patient will not be determined by cost-effectiveness studies, but by the surgeon basing the treatment decision on the unique stone

and patient factors, the resources available, and the surgeon's experience.

The primary focus of urologists when treating stones is to obtain the best clinical outcome. But costs should be a consideration when deciding on a treatment option for a particular patient. **The surgeon should decide how to treat a particular patient based on stone location, stone burden, stone composition, patient body habitus, intrarenal anatomy, surgeon skill and experience, and the hospital resources available to treat stones. Based on these factors, the urologist should determine which treatment option in their hands will achieve the best stone-free rate at the lowest cost.** Once the urologist decides which treatment to employ, they have great discretion in how the procedure is performed, which disposable equipment is utilized, and to some degree which capital equipment is utilized. These decisions will likely have more effect on the cost of the procedure than which procedure is performed.

Given the lack of cost information available to surgeons on the care they provide, surgeons currently have minimal opportunity to assess cost-effectiveness in their own practice. One approach to improving cost-effectiveness in the OR would be to provide accurate cost data to physicians in real time. Analyses of cost-effectiveness by surgeons can be significantly improved if the information inadequacies and organizational fragmentation between hospitals that buy the equipment and the surgeons who use the equipment are addressed. By having a better understanding of costs, surgeons are better able to choose which procedure to utilize for a particular patient and their stone burden, the treatment strategy during the procedure, and the capital equipment required to treat the stone in the most clinical and cost-effective manner.

## DID YOU KNOW?

- Physicians have direct or indirect control of more than 80% of health care spending. Surgical care accounts for 40% of all U.S. health care spending, and surgeons can therefore play a major role in decreasing health care costs. Treatment of stone disease is a resource-intensive area and represents a high-yield target to decrease expenditures.
- The most cost-effective method to treat stones is far from settled, and the most cost-effective method to treat a particular stone is largely dependent on the unique factors of the stone, the patient, and the surgeon treating the stone.
- Once the urologist decides which treatment to employ, they have great discretion in how the procedure is performed and which disposable equipment is utilized. These decisions will have as much and likely more effect on the cost of the procedure than which procedure is performed. One simple method to control costs is to open disposable equipment only when it is to be used.
- Analyses of cost-effectiveness by surgeons could be significantly improved if surgeons had a better understanding of costs. Surgeons would be better able to choose which procedure to utilize for a particular patient and their stone burden, the treatment strategy during the procedure, and the capital equipment required to treat the stone in the most clinical and cost-effective manner.

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# Study Questions Volume 42 Lesson 15

1. Disposable supplies, such as a ureteral access sheath, which surgeons choose to use during a procedure are examples of which type of cost?
   a. Direct variable
   b. Indirect variable
   c. Direct fixed
   d. Indirect fixed

2. Which of the following is a direct fixed cost?
   a. Disposable ureteroscope
   b. Guidewire
   c. Holmium laser
   d. Stone basket

3. Ureteral stent placement at the time of shock wave lithotripsy
   a. Increases costs
   b. Improves stone-free rates
   c. Decreases the risk of Steinstrasse
   d. Decreases the risk of perinephric hematoma

4. Percutaneous access by urologists is associated with higher
   a. Complication rates
   b. Rates of prolonged hospitalization
   c. Stone-free rates
   d. Costs

5. What is the minimum number of URS procedures needed annually for reusable ureteroscopes to have a cost advantage over disposable ureteroscopes?
   a. 60
   b. 80
   c. 100
   d. 120