

Surgical Management of Kidney and Ureteral Stones: AUA Guideline (2026). Part II: Evaluation and Treatment of Patients With Kidney and/or Ureteral Stones

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Abbreviations and Acronyms

ALARA = As Low As Reasonably Achievable

CBC = complete blood count

CT = computed tomography

ED = emergency department

PCNL = percutaneous nephrolithotomy

RCT = randomized controlled trial

SWL = shockwave lithotripsy

URS = ureteroscopy

UTI = urinary tract infection

SIRS = systemic inflammatory response syndrome

spm = shocks per minute

Purpose: This Guideline covers the surgical management of patients with kidney and/or ureteral stones and is intended for clinicians evaluating and managing patients with this disease. The summary presented herein represents Part II of the 3-part series dedicated to Surgical Management of Kidney and Ureteral Stones. Please refer to Parts I and III for additional information on this topic.

Materials and Methods: This systematic review was conducted in 2 planned stages, including a search for systematic reviews followed by a search for primary literature. OVID was used to systematically search MEDLINE and EMBASE databases for articles evaluating surgical management of kidney and ureteral stones. The Panel selected control articles that were deemed relevant and the articles were compared with the literature search strategy output. The methodologist then updated the strategy as necessary to capture all control articles. Databases were searched for studies published from January 2000 through May 2025 (week 20). In addition to the MEDLINE and EMBASE databases searches, reference lists of included systematic reviews and primary literature were scanned for potentially useful studies.

Results: The Panel addressed adult and pediatric patients with kidney and/or ureteral stones for whom surgical intervention may be indicated. Each statement herein addressed a particular patient scenario for which the choice of surgical intervention was reviewed and justified. In addition, the Panel reviewed

and analyzed the utility of specific surgical techniques, technologies, or medications aimed at improving patient outcomes.

Conclusions: Selection of optimal treatment modalities for patients with kidney and/or ureteral stones is determined by patient factors, urinary tract anatomy, and stone characteristics and are guided by shared decision-making that additionally takes into account patient goals and preferences, resource availability, and physician expertise. This Guideline serves as a resource for clinicians and patients to provide the best available evidence on which to base discussions with patients in a shared decision-making process to arrive at appropriate treatment decisions.

Key Words: kidney, calculi, urolithiasis, nephrolithiasis, urinary calculi, ureteral calculi, ureterolithiasis kidney stones, ureteral stones, urinary stones, kidney calculi, kidney calculus, renal calculus, percutaneous nephrolithotomy, shockwave lithotripsy, ureteroscopy, lithotripsy, ureterolithotomy, retrograde intrarenal surgery, percutaneous nephrostomy, ureteral access sheath, medical expulsive therapy, diagnostic imaging, molecular imaging, ultrasonography, MRI, KUB

GUIDELINE STATEMENTS

Note: information on meta-analyses conducted for the purposes of this Guideline are available with the full Guideline at www.AUANet.org/Guidelines.

Treatment of Patients With Kidney Stones

For adult patients with kidney stones undergoing percutaneous nephrolithotomy (PCNL), clinicians may omit nephrostomy tube placement, regardless of whether or not a ureteral stent is placed. (Conditional Recommendation; Evidence Level: Grade A)

A Cochrane systematic review of 10 randomized controlled trials (RCTs) and quasi-RCTs compared the outcomes of tubeless (stent, but no nephrostomy tube), totally tubeless (no tubes), and standard PCNL (nephrostomy tube with or without stent) and found no significant differences in severe adverse events, post-operative day 1 pain scores, blood transfusions, sepsis or fever, and readmissions between tubeless and standard approaches.¹ However, postoperative day 1 pain

scores were lower in the totally tubeless compared to standard PCNL group. Tubeless and totally tubeless PCNL were associated with shorter hospitalization compared to the standard PCNL group.¹ Three additional RCTs published after the Cochrane review compared totally tubeless to standard PCNL and variably showed less analgesic use,^{2,3} shorter hospital length of stay,^{2,3} less post-operative pain,³ and shorter return to normal activity³ in the totally tubeless groups, with no difference in blood loss between groups.⁴

The Panel recognizes that multiple factors may determine which approach is chosen by the surgeon and recommends that renal drainage decisions should be based on surgeon preference and specific patient and case considerations.

For adult patients undergoing PCNL, clinicians may obtain a computed tomography (CT) in the immediate/early post-operative period to assess stone-free status and determine the need for a secondary procedure. (Expert Opinion)

Submitted October 28, 2025; accepted November 1, 2025; published November 20, 2025.

The complete unabridged version of the guideline is available at auanet.org/StonesSurgicalManagement.

This document is being printed as submitted, independent of standard editorial or peer review by the editors of *The Journal of Urology*®.

Funding/Support: None.

Conflict of Interest Disclosures: All panel members completed COI disclosures. Disclosures listed include both topic- and non-topic-related relationships. Consultant/Advisor: Dr Chi, Boston Scientific Corporation, Auris, Bard Medical, Dornier, Cook, Lumenis, Vibronix, Mendaera, UroViu, Calyxo, Adromeda Surgical; Dr Knudsen, Olympus Surgical; Dr Scotland, Advanced Medtech, Karl Storz; Dr Tasian, Dicerna, Inc, Alnylam; Dr Wood, Oxalosis and Hyperoxaluria Foundation. Scientific Study or Trial: Dr Hsi, NIH; Dr Knudsen, ADVA-TEC, Inc; Dr Maalouf, NIH-NIDDK. Leadership Position: Dr Matlaga, Endourological Society; Dr Penniston, NIH; Dr Scotland, NIH-NIDDK, MicrogenDX; Dr Streeper, NIH; Dr Tasian, NIH, PCORI; Dr Wood, NIH. Health Publishing: Dr Antonelli, *Journal of Urology*®, AUA Core Curriculum Editorial Committee; Dr Koo, UpToDate, American Urological Association, *Canadian Journal of Urology International*; Dr Maalouf, UpToDate; Dr Matlaga, Urologic Clinics of North America; Dr Pais, Clinical Nephrology; Dr Pearle, *Journal of Endourology*, Urolithiasis/Springer; Dr Wood, Current Urology Reports. Investment Interest: Dr Pais, Sonomotion; Dr Paris, Abbvie, CVS, Glaxo Smith Kline, Pfizer, United Health Group; Dr Ziembra, Moderna, Walgreens Boots Alliance. Other: Dr Antonelli, Duke University; Dr Chi, American Urological Association; Dr Koo, NIH, Verana Health, AUA North Central Section; Dr Pearle, Blue Cross Blue Shield of Michigan; Dr Penniston, American Urological Association Research, Education, Conferences, and Communication Committee.

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Surgeon assessment of residual fragments during PCNL, based on intraoperative findings and fluoroscopy, has been shown to have poor sensitivity (24%-50%) compared to immediate/early post-operative non-contrast CT imaging.^{5,6} Moreover, surgeons commonly underestimate the size of clinically significant residual fragments,⁷ which are known to confer a higher risk of re-intervention and unplanned stone events.⁸⁻¹⁰ As such, use of post-operative CT imaging may inform the need for and planning of secondary procedures aimed at rendering the patient stone-free and may additionally identify organ injury after PCNL. Use of low-dose CT protocols should be considered to minimize cumulative radiation exposure during the treatment period.

Treatment of Patients With Kidney and/or Ureteral Stones

In adult and pediatric patients with kidney and/or ureteral stones, clinicians should minimize ionizing radiation during surgical stone procedures using radiation-reducing techniques. (Expert Opinion)

As Low As Reasonably Achievable (ALARA) principles should be practiced in all cases utilizing ionizing radiation to limit radiation exposure to the patient, surgeon, and staff. Education on ALARA principles and appropriate radiation protection is paramount. The most effective means of reducing radiation exposure is by reducing fluoroscopy time. Ensuring the X-ray tube is below the patient, using pulsed fluoroscopy, placing the image intensifier close to the patient, utilizing last-image hold, selecting “low dose” fluoroscopy, and using collimation to create a reduced field are additional strategies for reducing exposure. The staff should maintain a safe distance from the radiation source, and all operating personnel should wear protective lead shielding garments, including thyroid shields. Protective lead eye wear can be considered.

Clinicians should inform adult and pediatric patients with kidney and/or ureteral stones that ureteroscopy (URS) is associated with a higher stone-free rate than shockwave lithotripsy (SWL). (Strong Recommendation; Evidence Level: Grade B)

The data reviewed for this Guideline showed that overall, URS is associated with higher stone-free rates compared to SWL for the treatment of patients with kidney and ureteral stones.¹¹⁻²¹ Furthermore, retreatment rates are lower for URS compared to SWL.^{11,12} A meta-analysis prepared for this Guideline found an overall higher stone-free rate with URS compared to SWL, a finding that was confirmed for lower pole calyceal and proximal ureteral stones as well (refer to full Guideline). Comparative outcomes for patients undergoing URS

or SWL for other subcategories of patients, such as those with non-lower pole stones, upper pole stones or mid-ureteral stones, were sparse during the timeframe of evaluation for this Guideline.

SWL has also been shown to have higher rates of retreatment and auxiliary procedures than URS for stones of all sizes,¹⁹ although length of hospital stay^{11,22} and operating time is shorter for SWL²² in both adult and pediatric patients. Our analysis found no significant difference in the overall rate of complications associated with SWL vs URS.^{11,16,18,19} Despite superior stone-free rates for URS compared to SWL, clinicians may choose to proceed with SWL after taking into account patient priorities identified during the shared decision-making process.

Of note, stone composition should also be considered, since cystine stones in particular can prove resistant to fragmentation with SWL,²³ and both cystine and uric acid stones may be insufficiently radio-opaque for identification via fluoroscopic-guided SWL.

In adult patients with kidney or ureteral stones in whom ureteroscopic, extracorporeal, or percutaneous treatment is unavailable, unsuccessful, or limited by patient factors, clinicians may perform a laparoscopic/robotic pyelolithotomy or ureterolithotomy. (Conditional Recommendation; Evidence Level: Grade C)

The Panel recognizes that at some institutions, the only option for kidney stone management involves open surgery, with no practical option to transfer the patient to a center of excellence where other treatment modalities are available. However, endoscopic management of kidney stones has been shown to decrease postoperative patient morbidity compared to open surgery. Thus, in institutions where endoscopic equipment is available, it should be preferentially used.

However, there are limited circumstances for which SWL or endoscopic procedures are prohibitive or are unlikely to be successful in removing stones, including lack of necessary equipment for endoscopic surgery, or patient factors such as unfavorable body habitus or renal anatomy, that render these procedures particularly challenging. While there continues to be little evidence supporting the use of open surgery in these cases, there are recent data suggesting that laparoscopic or robotic pyelolithotomy or ureterolithotomy can provide efficient stone clearance with low complication rates in some cases.²⁴⁻²⁶

For adult patients with kidney or ureteral stones undergoing SWL, clinicians may omit preoperative prophylactic antibiotics. (Conditional Recommendation; Evidence Level: Grade B)

SWL is a non-invasive procedure that does not require routine use of preoperative antibiotic prophylaxis in the absence of preoperative evidence of

UTI.²⁷ A meta-analysis of 9 RCTs found no significant differences in the incidence of postoperative fever, positive urine culture, or clinical UTI when antibiotic prophylaxis was compared with placebo or no treatment in patients undergoing SWL without evidence of preoperative UTI.²⁸ These findings were confirmed in a large retrospective cohort study in whom the use of preoperative antibiotic prophylaxis did not impact the incidence of post-SWL UTI or sepsis.²⁹ When ureteral instrumentation is planned during SWL (such as insertion of ureteral stent or performance of a retrograde pyelogram), administration of preoperative antibiotics should be considered.

Although the systematic review for this Guideline did not capture any relevant evidence on pediatric patients to support this recommendation, the Panel believes that the risk of UTI after SWL is low, and routine preoperative antibiotic prophylaxis is not required in pediatric patients undergoing SWL.

For adult patients with kidney or ureteral stones undergoing URS and PCNL, clinicians should administer preoperative prophylactic antibiotics. (Moderate Recommendation; Evidence Level: Grade B)

Because URS and PCNL involve instrumentation of the urinary tract which increases the risk of postoperative infectious complications, routine antimicrobial prophylaxis is recommended.

For patients undergoing URS, a single preoperative, prophylactic oral or IV dose of an antibiotic based on the local antibiogram is recommended for patients without signs of infection.²⁷ In this patient population, a single pre-operative dose of prophylactic antibiotic significantly reduced the rates of pyuria and bacteriuria, but not of febrile UTI compared with no antibiotic use in a meta-analysis of 4 RCTs.³⁰ The use of an additional post-operative antibiotic did not provide additional reduction in the incidence of post-URS UTI in patients already receiving a single preoperative antibiotic.^{31,32} However, in patients with evidence of infection, a longer preoperative antibiotic regimen lowers the incidence of UTI and sepsis,^{33,34} and is therefore indicated prior to URS.

For patients undergoing PCNL, a single preoperative, prophylactic dose of antibiotic is recommended in low-risk patients (those with no indwelling urinary drain and with sterile preoperative urine) to minimize the risk of infectious complications.²⁷ However, because some patients with negative voided pre-operative urine cultures have positive kidney stone cultures, potentially contributing to UTI and sepsis post-PCNL,³⁵ several studies have examined whether a longer perioperative course of oral antibiotics in addition to the single preoperative prophylactic antibiotic provides

additional protection against post-PCNL infections. In a meta-analysis of 3 RCTs and 2 prospective studies, 7 days of oral antibiotics preceding PCNL reduced the incidence of positive intraoperative urine culture, stone culture, and sepsis compared to the control group.³⁶ However, the largest study in this meta-analysis included only patients at moderate-high infectious risk undergoing PCNL.³⁷ Likewise, another meta-analysis confirmed a lower incidence of systemic inflammatory response syndrome with an extended course of perioperative antibiotics compared to a single preoperative dose but found that this reduction was primarily driven by benefit in high-risk patients and did not show benefit in low-risk patients.³⁸ Additional studies confirm that in patients with low infectious risk undergoing PCNL, there is no additional benefit of a 3-day course of preoperative oral antibiotics,³⁹ or from extending antibiotic use beyond 24 hours post-PCNL.⁴⁰ Thus, a single preoperative dose of an appropriate antibiotic is recommended for low-risk patients undergoing PCNL. However, in patients with high infectious risk undergoing PCNL, the choice and duration of the antimicrobial agent should be based on the local antibiogram, prior urine culture results, and the pharmacokinetics of the selected agent.

Although the systematic review for this Guideline did not capture any relevant evidence on pediatric patients to support this recommendation, the Panel recommends the routine use of preoperative antibiotic prophylaxis in pediatric patients undergoing URS and PCNL as well.

For adult and pediatric patients with obstructing stones and suspected infection, clinicians should obtain a complete blood count, basic metabolic panel, urinalysis, and urine culture to assess for infection and guide clinical decision-making. (Expert Opinion)

In patients with obstructing stones and suspected infection, a urinalysis should be obtained to assess for pyuria, leukocyte esterase, and nitrites as these can be indicators of infection. While imperfect, urinalysis offers timely information upon which to act whereas urine culture, although essential for identifying causative pathogens and guiding targeted antibiotic therapy, is not typically available immediately.

Leukocytosis and leukopenia, and in some cases thrombocytopenia, identified on a complete blood count have been associated with systemic infection. Assessment of renal function and serum chemistries from a basic metabolic panel can identify renal dysfunction from obstruction as well as electrolyte imbalances, both of which can impact antibiotic selection and dosing. Optional studies, such as serum

inflammatory markers (C-reactive protein) and procalcitonin, may aid in predicting infectious complications in patients with obstructing urolithiasis, although further research is needed to establish their clinical utility.^{41,42}

The Panel's clinical judgment and experience suggest the recommendation may also be applicable to pediatric patients.

For adult patients with obstructing kidney and/or ureteral stones and suspected infection, clinicians should initiate urgent renal drainage. (Strong Recommendation; Evidence Level: Grade C).

For adult patients with obstructing kidney and/or ureteral stones and suspected infection, clinicians may drain the collecting system with either a nephrostomy tube or ureteral stent. (Conditional Recommendation; Evidence Level: Grade A).

For adult and pediatric patients with obstructing kidney and/or ureteral stones and suspected infection undergoing urgent drainage of the collecting system, clinicians should obtain a urine sample from the collecting system for culture, when possible. (Expert Opinion).

Attempting to surgically remove an obstructing stone in the presence of an untreated UTI can lead to life-threatening sepsis. Conversely, treating the infection with antibiotics alone without addressing an obstruction is unlikely to resolve the infection and may allow continued clinical deterioration. In these cases, it is essential that patients receive both culture-directed antimicrobial therapy and undergo urgent renal drainage via a ureteral stent or nephrostomy tube.^{43,44} Data from the National Inpatient Sample showed that among patients with a kidney or ureteral stone with a UTI and hydronephrosis, the highest mortality rate occurred in patients presenting with septic shock who did not undergo renal decompression (13.6%) compared to the lowest mortality rate in non-septic patients who underwent drainage (0.2%). On multivariable analysis, delaying renal decompression by 2 or more days was associated with a 29% increase in the odds of death (Odds Ratio: 1.29; 95% CI: 1.03-1.63; $P = .032$).⁴⁵

Once the kidney has been decompressed, definitive surgical stone removal should be delayed until the infection is fully treated with an appropriate course of antimicrobial therapy, and all signs of sepsis or infection-related complications have resolved.

The decision to place a nephrostomy tube or a ureteral stent for urinary drainage in the setting of an obstructing stone and suspected UTI should be based on the available urologic and interventional radiology resources, as well as anatomic, stone, and patient

specific factors. Two RCTs showed no significant difference in clinical outcomes between the 2 approaches for urinary drainage in this setting.^{43,46}

The diagnostic yield of urine cultures obtained directly from the collecting system can be higher than that of voided specimens in the setting of an obstructing stone, possibly because the obstructing stone may prevent bacteria from reaching the bladder and appearing in a midstream sample. Therefore, when feasible, obtaining a urine sample proximal to the obstructing stone for culture at the time of renal decompression may yield the highest diagnostic value.

Although relevant pediatric data were lacking in the evidence report informing the recommendations for urgent drainage of the collecting system, the Panel's clinical judgment and experience suggest these recommendations are applicable to pediatric patients.

For adult patients undergoing URS or PCNL for a primary, symptomatic ureteral or kidney stone, clinicians should offer concurrent URS removal of secondary, asymptomatic non-obstructing kidney stones <6 mm in either kidney during the same surgical session. (Moderate Recommendation; Evidence Level: Grade B)

Sorensen et al compared immediate, same session ipsilateral or contralateral URS for removal of secondary kidney stones (≤ 6 mm) with observation and active surveillance of these stones.⁴⁷ Same-session surgical intervention resulted in a lower incidence of relapse at a longer time interval compared to observation. Although treatment of the asymptomatic stones was associated with a small increase in operative time, there was no difference in the rate of postoperative complications, such as emergency department visits, between the 2 groups.⁴⁷ However, clinicians should be cautious about extrapolating this data to patients with larger (>6 mm) or more numerous secondary ipsilateral or contralateral kidney stones as these clinical scenarios were not addressed in this trial.

Since an equivalent trial does not exist in the pediatric population, extrapolating this data to children cannot be supported.

For adult patients with bilateral kidney and/or ureteral stones, clinicians may offer bilateral same-session stone treatment. (Conditional Recommendation; Evidence Level: Grade B)

Bilateral URS with laser lithotripsy has been shown to be a safe and effective option for managing bilateral kidney stones in appropriately selected patients.⁴⁸⁻⁵⁰ A systematic review and meta-analysis found that bilateral same-session URS had similar stone-free rates compared to unilateral URS but with higher rates of minor and major complications, and higher rates of retreatment.⁵¹

Likewise, bilateral same session PCNL was shown to have comparable stone clearance, complication rates, and renal functional outcomes compared to unilateral PCNL, although bilateral PCNL was associated with longer operative times and greater blood loss, underscoring the importance of careful patient selection, meticulous perioperative management, and performance by experienced surgeons at high-volume centers.⁵²⁻⁵⁴ For both URS and PCNL, surgeons should be prepared to forego the procedure on the contralateral side if operative time is prolonged, complications occur, and/or patient condition deteriorates.

Same-session bilateral SWL has been shown to be safe and effective when proper patient selection and procedural protocols are followed. No significant differences in renal functional outcomes or the risk of bilateral renal obstruction have been observed in single session vs staged bilateral SWL.^{55,56}

For adult and pediatric patients undergoing bilateral stone surgery or surgery in a functionally solitary kidney, clinicians should place a ureteral stent. (Expert Opinion)

To prevent acute kidney injury, the Panel recommends placement of at least 1 ureteral stent in patients undergoing bilateral procedures or surgery on a functionally solitary kidney. The Panel's clinical judgment and experience suggest the recommendation may also be applicable to pediatric patients.

For adult patients with kidney and/or ureteral stones undergoing SWL, clinicians should not place a ureteral stent with the intention of improving stone-free rate. (Clinical Principle)

A 2011 meta-analysis consisting of 8 RCTs and 876 patients comparing stented vs unstented SWL for kidney and ureteral stones found no significant difference in stone-free rate between groups, but did show a higher incidence of lower urinary tract symptoms in the stented group compared to the unstented group.⁵⁷

Although there may be an indication for some patients to undergo stent placement prior to SWL, such as functionally or anatomically solitary kidney or pain and/or obstruction, the Panel reiterates the prior Guideline recommendation that routine ureteral stenting prior to SWL with the intention of improving stone-free rate is not recommended.⁵⁸

For adult and pediatric patients undergoing SWL for kidney or ureteral stones, clinicians should employ a slow shockwave strategy to optimize stone clearance and minimize complications. (Moderate Recommendation; Evidence Level: Grade C)

Several clinical trials in adults with kidney and ureteral stones demonstrated that administering shocks at a rate of 60 shocks per minute (spm) resulted in greater stone clearance (likely due to better fragmentation) than delivering shocks at higher rates of 80 spm⁵⁹ or 120 spm⁶⁰⁻⁶⁴ (refer to full Guideline). Additionally, 1 trial showed that a slower shock wave rate (60 spm) resulted in less pain and fewer emergency department visits than a higher shock wave rate (120 spm).⁶¹ A trial in pediatric patients also demonstrated higher stone clearance rates in slower compared to faster shockwave rates (80 spm vs of 120 spm).⁶⁵

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