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051IC - AUA Guidelines Update on the Surgical and Medical Management of Kidney Stones: Case-based Scenarios and Complex Cases

Sunday, May 17

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AUA GUIDELINES:

SURGICAL AND MEDICAL MANAGEMENT OF STONES & COMPLEX CASES

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Course Content

- Introduction of NEW guidelines
  - Major differences between NEW and PRIOR guidelines
- Treatment choices
  - Observation
  - SWL
  - Ureteroscopy
  - PCNL
- Medical management and prevention
- New concepts

AUA Guidelines and Complex Cases

- Lower pole renal stones
- Bilateral kidney stones
- Ureteral stones
- Non-obstructing calyceal stones with pain
- Stones in Pregnancy
- Fluid intake
- Uric acid stone management
- Management of hypercalciuria
- Stones and recurrent UTIs
- Non-opioid pain management pathways
- Laser technology options
- Mini-PCNL vs URS
- Next generation ureteral access sheaths
- Ureteroscopy with suction
- SWL and failed SWL management
- Radiation reducing techniques
- Postintervention imaging

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Authors' disclosure of potential conflicts of interest and author/staff contributions appear at the end of the article.

Surgical Management of Kidney and Ureteral Stones: AUA Guideline (2026)

Guideline Panel

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SUMMARY

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.

METHODOLOGY

This systematic review was conducted in two 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. In addition to the MEDLINE and EMBASE databases searches, reference lists of included systematic reviews and primary literature were scanned for potentially useful studies.

GUIDELINE STATEMENTS

PRE-OPERATIVE EVALUATION AND PREPARATION

1. For adult and pediatric patients undergoing surgical intervention for kidney and/or ureteral stones, clinicians should obtain a medical history, perform a relevant physical examination, and obtain laboratory studies appropriate to procedural risk and patient comorbidities. (*Clinical Principle*)
2. For adult and pediatric patients with kidney and/or ureteral stones, clinicians should obtain a urinalysis and/or urine culture prior to surgical intervention. (*Clinical Principle*)
3. For adult and pediatric patients with kidney and/or ureteral stones and untreated bacteriuria/funguria, clinicians should not proceed with definitive stone surgery. (*Clinical Principle*)
4. For adult patients with kidney and/or ureteral stones, clinicians may obtain cross-sectional imaging to guide surgical treatment selection. (*Conditional Recommendation; Evidence Level: Grade C*)
5. For adult patients undergoing percutaneous nephrolithotomy (PCNL) for kidney and/or ureteral stones, clinicians should obtain a computed tomography (CT) prior to surgery. (*Moderate Recommendation; Evidence Level: Grade C*)
6. For adult and pediatric patients undergoing surgical intervention, clinicians should assess differential renal function if there is suspicion of clinically relevant loss of renal function in the involved kidney. (*Expert Opinion*)

TREATMENT OF PATIENTS WITH URETERAL STONES

7. For adult and pediatric patients with ≤10 mm distal ureteral stones, clinicians should offer medical expulsive therapy (MET) with alpha-adrenergic blockers for approximately 30 days to facilitate stone passage. (*Strong Recommendation; Evidence Level: Grade A*)
8. For adult patients with ≤10 mm stones in the middle and proximal ureter, clinicians may offer MET with alpha-adrenergic blockers for approximately 30 days to facilitate stone passage. (*Conditional Recommendation; Evidence Level: Grade B*)
9. When surgical treatment is indicated for adult patients with distal ureteral stones ≤10 mm, clinicians may offer ureteroscopy (URS) or shockwave lithotripsy (SWL). (*Conditional Recommendation; Evidence Level: Grade B)*
10. When surgical treatment is indicated for adult patients with <2 cm proximal ureteral stones, clinicians may offer URS or SWL. (*Conditional Recommendation; Evidence Level: Grade B*)
11. For adult patients with ureteral stones in whom SWL fails to result in complete stone clearance, clinicians may offer a second SWL procedure or proceed to URS. If a second SWL procedure fails, clinicians should offer URS. (*Conditional Recommendation; Evidence Level: Grade C*)
12. For adult and pediatric patients with >2 cm ureteral stones or with ureteral stones that have not been successfully treated with previous retrograde URS or SWL or are not amenable to these procedures, clinicians should offer a percutaneous antegrade approach. (*Expert Opinion*)

TREATMENT OF PATIENTS WITH KIDNEY STONES

13. For adult patients with flank pain and non-obstructing kidney stones on the ipsilateral side who have no other identifiable source of pain, clinicians may offer elective surgical treatment. (*Conditional Recommendation; Evidence Level: Grade C*)

14. For adult and pediatric patients with asymptomatic non-obstructing kidney stones, clinicians may offer either active surveillance or pre-emptive surgical intervention. (*Conditional Recommendation; Evidence Level: Grade C*)

15. For adult patients with recurrent or persistent urinary tract infections (UTIs) and non-obstructing calyceal stones, clinicians may offer elective surgical stone removal for the purpose of reducing the risk of recurrent UTIs. (*Conditional Recommendation; Evidence Level: Grade C*)

16. For adult patients undergoing SWL for kidney stones, clinicians may initiate treatment with low energy shockwaves and gradually increase the energy during the session in order to reduce the risk of bleeding complications. (*Conditional Recommendation; Evidence Level: Grade C*)

17. For adult patients with <1 cm lower pole kidney stones, clinicians may offer SWL, URS, or a percutaneous approach after engaging in shared decision-making. (*Expert Opinion*)

18. For adult patients with >1 cm lower pole or >2 cm non-lower pole kidney stones, clinicians should not offer SWL as first-line therapy. (*Expert Opinion*)

19. For adult patients with >1 cm lower pole kidney stones, clinicians should inform the patient that PCNL is associated with a higher stone-free rate than SWL or URS. (*Strong Recommendation; Evidence Level: Grade A*)

20. For adult patients with <2 cm lower pole stones undergoing URS with laser lithotripsy, clinicians should, when feasible, reposition the stone to a more superior location prior to lithotripsy. (*Moderate Recommendation; Evidence Level: Grade B*)

21. For adult patients with 1 to 2 cm kidney stones, clinicians may offer mini-percutaneous nephrolithotomy (mini-PCNL), when available, over URS because of higher stone-free rates. (*Conditional Recommendation; Evidence Level: Grade B*)

22. For adult patients with >2 cm kidney stones, clinicians should recommend PCNL as first-line therapy. (*Moderate Recommendation; Evidence Level: Grade B*)

23. For adult patients undergoing PCNL for kidney stones up to 3 cm in size, clinicians may offer standard or mini-PCNL. (*Conditional Recommendation; Evidence Level: Grade B*)

    Clinicians should inform these patients that mini-PCNL has stone-free rates comparable to standard PCNL but is associated with fewer complications, less pain, and shorter length of stay, but with a longer operative time. (*Moderate Recommendation; Evidence Level: Grade C*)

24. Clinicians may perform PCNL in adult patients without discontinuing daily low dose aspirin. (*Conditional Recommendation; Evidence Level: Grade C*)

25. For adult patients undergoing PCNL for kidney stones, clinicians may administer systemic tranexamic acid (TXA) at the time of PCNL to reduce blood loss, provided they have no contraindications. (*Conditional Recommendation; Evidence Level: Grade A*)

26. For adult patients undergoing PCNL, clinicians may utilize either prone or supine positioning. (*Conditional Recommendation; Evidence Level: Grade B*)

27. For adult patients undergoing PCNL for kidney stones, clinicians may utilize intraoperative ultrasound (US), fluoroscopy, or combination image guidance for access. (*Conditional Recommendation; Evidence Level: Grade B*)

28. When performing mini-PCNL in adult patients with kidney or proximal ureteral stones, clinicians may utilize a suction sheath, when available, to improve stone-free rates and reduce the need for secondary procedures. (*Conditional Recommendation; Evidence Level: Grade C*)

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

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

TREATMENT OF PATIENTS WITH KIDNEY AND/OR URETERAL STONES

31. 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*)

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

33. 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*)

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

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

36. 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*)

37. 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*)

38. 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*)

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

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

41. 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*)

42. 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*)

43. For adult patients undergoing SWL for kidney and/or ureteral stones, clinicians should prescribe post-operative alpha-adrenergic blockers to improve stone-free rates and reduce post-operative pain. (*Strong Recommendation; Evidence Level: Grade B*)

44. Clinicians may perform URS for adult patients with kidney and/or ureteral stones who have uncorrected bleeding diatheses or who require continued anticoagulant (AC)/antiplatelet (AP) therapy. (*Conditional Recommendation; Evidence Level: Grade C*)

45. For adult patients with kidney and/or ureteral stones, clinicians may offer primary URS without prior stent placement. (*Expert Opinion*)

46. For adult patients with kidney and/or ureteral stones undergoing URS, clinicians may use a ureteral access sheath (UAS). (*Conditional Recommendation; Evidence Level: Grade B*)

47. For adult patients with kidney and/or ureteral stones undergoing URS with a UAS, clinicians may choose a flexible and navigable suction UAS. *(Conditional Recommendation: Evidence Level: Grade C)*

48. Clinicians may use a single-use flexible ureteroscope or reusable flexible ureteroscope for adult patients undergoing URS for kidney and/or ureteral stones. (*Conditional Recommendation; Evidence Level: Grade A*)

49. For adult patients undergoing URS with laser lithotripsy for kidney and/or ureteral stones, clinicians may utilize either a holmium:YAG or thulium fiber laser. (*Conditional Recommendation; Evidence Level: Grade C*)

50. For adult and pediatric patients undergoing URS with laser lithotripsy for kidney and/or ureteral stones, clinicians should utilize laser settings with the lowest total power that will accomplish clinical stone ablation. (*Expert Opinion*)

51. For adult and pediatric patients undergoing URS with laser lithotripsy for kidney and/or ureteral stones, clinicians may utilize a strategy of fragmenting and basketing or "dusting". (*Conditional Recommendation; Evidence Level: Grade B*)

52. For adult patients with kidney and/or ureteral stones, clinicians may omit post-operative ureteral stent placement following uncomplicated URS. (*Conditional Recommendation; Evidence Level: Grade C*)

53. For adult and pediatric patients undergoing surgical intervention for kidney and/or ureteral stones, clinicians should obtain stone for analysis when possible. *(Clinical Principle)*

54. For adult patients undergoing surgical intervention for kidney and/or ureteral stones, clinicians should utilize a multi-modal, non-opioid analgesic regimen and minimize use of opioids for post-operative pain management. (*Moderate Recommendation; Evidence Level: Grade C*)

55. For adult and pediatric patients undergoing surgical intervention for kidney and/or ureteral stones, clinicians should order follow-up imaging to assess residual stone burden and to identify hydronephrosis or other procedure-related complications. (*Expert Opinion*)

56. For adult and pediatric patients with residual stones after undergoing surgical intervention for kidney and/or ureteral stones, clinicians should offer secondary endoscopic removal of residual fragments and engage in shared decision-making, taking into account the benefits and risks. (*Moderate Recommendation; Evidence Level: Grade C*)

TREATMENT OF PREGNANT PATIENTS WITH KIDNEY AND/OR URETERAL STONES

57. For pregnant patients with suspected symptomatic kidney and/or ureteral stones, clinicians should utilize US as first-line imaging. If further imaging is indicated, non-contrast magnetic resonance imaging (MRI) or CT are both appropriate alternatives. (*Expert Opinion*)

58. For pregnant patients with symptomatic kidney and/or ureteral stones, clinicians should coordinate pharmacologic and/or surgical intervention with the obstetrician. (*Clinical Principle*)

59. For pregnant patients with kidney and/or ureteral stones and well controlled symptoms, clinicians should offer observation with a trial of stone passage. (*Clinical Principle*)

60. For pregnant patients with ureteral stones for whom a trial of passage is unsuccessful or who are not candidates for a trial of passage, clinicians may offer URS. Placement of a ureteral stent or nephrostomy tube, with frequent tube changes, may be offered as an alternative to URS. (*Conditional Recommendation; Evidence Level: Grade C*)

INTRODUCTION

BACKGROUND

Approximately 1 in 9 individuals in the United States will be diagnosed with a kidney or ureteral stone at some time in their lives, and there is evidence that this number is rising in some populations, including women.[1-3] Although some stones remain asymptomatic and are evident only as an incidental finding on imaging studies obtained for unrelated reasons, others are manifested through episodes of pain, infection or loss of kidney function. Acute symptoms from kidney or ureteral stones are responsible for over one million emergency department (ED) visits annually in the US,[4] with a 17.9% increase in ED visits documented between 2006 and 2014.[5] Many of these visits culminate in hospital admission and/or surgical intervention, underscoring the heavy economic burden on the healthcare system attributable to stone disease. Indeed, over 370,000 commercially insured individuals and Medicare beneficiaries underwent surgery for stones in 2019, with the majority of procedures comprised of URS.[1] However, absolute increases in the number of patients undergoing both URS and PCNL have been observed, while absolute numbers of SWL procedures and the proportion of stone procedures performed as SWL declined from 2011 to 2019.[1]

Safe, efficient, and cost-effective management of symptomatic and/or high risk renal and ureteral stones (i.e., large, obstructing, renal pelvis or ureteral, or infection-related stones or stones in anatomically or functionally solitary kidneys) requires careful planning based on patient history and relevant diagnostic imaging. Patient factors, anatomic considerations and stone characteristics will determine the optimal timing and selection of surgical treatment modalities. Furthermore, appropriate and timely follow-up determines the success and identifies complications of surgical intervention. The American Urological Association (AUA) has been committed to providing evidence-based recommendations for the comprehensive surgical management of patients with kidney and/or ureteral stones, including the decision to observe, rather than to treat select patients, since publication of the initial Guidelines on Management of Staghorn Calculi in 2005 and Ureteral Calculi in 2007.[6, 7] The prior Surgical Management of Stones Guideline, which incorporated recommendations for the treatment of patients with kidney and/or ureteral stones, was released in 2016 and was based on peer-reviewed literature from 1/1/1985 to 5/31/2015.[8] In the current Guideline, the literature search included articles published between January 2000 through May 2025. The overlap of articles published between 2000 and 2015 between the two Guidelines was primarily because most SWL literature was published before 2015, and some other relevant key trials that have not been replicated fell within that time frame. The Panel's intention was not to simply expand upon the previous systematic review from the 2016 Guideline, but rather to limit the search to a time frame that reflects modern endoscopic and non-invasive surgical modalities. While this limited search may miss some important historical findings from older relevant published studies, the intention of the Panel was to utilize the best contemporary evidence available on which to base the recommendations. In addition, consistent with the prior Guideline, the Panel included SWL among "surgical" stone treatments, despite its non-invasive nature, based on general convention.

In order to provide evidence-based recommendations that encompass the most common clinical patient scenarios, the Panel specified the patient population for which each statement is intended. However, unless otherwise specified, the population addressed in the Guideline statements should be assumed to be non-pregnant with an anatomically normal urinary tract. The lack of extensive published data on the surgical management of stones in pediatric patients precluded a clear set of Guideline recommendations in this patient population. Consequently, where sufficient data exist to support evidence-based directives for pediatric patients, separate Guideline statements were developed. However, when sufficient evidence was unavailable, but the Panel surmised that the recommendations for adult patients could be reasonably applied to the pediatric population based on Expert Opinion, their recommendations were added to the supporting documentation for the corresponding Guideline statements based on evidence in the adult population.

For the purposes of this Guideline, ureteral stone locations are categorized as *proximal* –extending from the ureteropelvic junction to the superior border of the sacroiliac joint; *middle* – overlying the bony pelvis; and *distal* – from the inferior border of the sacroiliac joint to the ureterovesical junction.

METHODOLOGY

Determination of the Guideline scope and assessment of the final systematic review to inform Guideline statements was conducted in conjunction with the Stones Guideline Panel. The systematic review utilized to inform this Guideline and methodological support was provided by an independent methodological consultant.

Panel Formation

The Panel was created in 2023 by the American Urological Association Education and Research, Inc. (AUAER). The Practice Guidelines Committee (PGC) of the AUA selected the Panel Chairs who in turn appointed the additional panel members following an open nomination process to identify members with specific expertise in this area. This is a multidisciplinary panel that includes representation from urology/endourology, endocrinology, and urology nutrition, in addition to patient representation. Funding for the Panel was provided by the AUA; panel members received no remuneration for their work.

Searches and Article Selection

As stated above, the systematic review that informs the Guideline statements was conducted in two planned stages, including a search for systematic reviews followed by a search for primary literature. An initial search was conducted for existing systematic reviews in March 2024 and an updated search was conducted to capture studies through May 2025. Systematic reviews published as a component of practice guidelines were also considered eligible for inclusion. An electronic search employing OVID was used to systematically search the MEDLINE and EMBASE databases, as well as the Cochrane Library, for systematic reviews evaluating surgical management of kidney and ureteral stones.

OVID was used to systematically search MEDLINE and EMBASE databases for articles evaluating surgical management of kidney and ureteral stones using the population, interventions, comparisons, and outcomes (PICO) as outlined below. During PICO development, panel members submitted landmark studies addressing the Key Questions to the methodologist. These studies were defined as control articles and were used to harvest terms for the search strategy. Additionally, the literature search strategy output was compared to the control articles to test for precision and recall in the search, with the strategy being updated as necessary to capture all control articles. Databases were searched for studies published from January 2000 through May 2025. In addition to the MEDLINE and EMBASE databases searches, reference lists of included systematic reviews and primary literature were scanned for potentially useful studies.

All articles identified from the OVID literature search were entered into reference management software (EndNote 21), where duplicate citations were removed. Abstracts were reviewed by the methodologist to determine if the study addressed the Key Questions and if the Patient, Intervention, Comparison, and Outcome (PICO) criteria were met. For all research questions, randomized controlled trials (RCTs), observational studies, and case-control studies were considered for inclusion in the evidence base. Single arm studies were only considered for Key Questions where a paucity of comparative studies was expected. All studies had to enroll at least 30 patients per study arm. Case series, letters, editorials, in vitro studies, studies conducted in animal models, and studies not published in English were excluded from the evidence base a priori.

Full-text review was conducted on studies that passed the abstract screening phase. Fifteen panel members were paired with the methodologist and completed duplicate full-text study selections of 50 random studies undergoing full-text review. The dual-review trained the methodologist, who then completed full-time review of the remaining studies.

Following the full-text review, 25 systematic reviews met the study selection criteria and were included in the evidence base.

The primary literature review was used to address all outcomes not covered by the included systematic reviews. It was anticipated that primary literature would report on outcomes in addition to what was pooled in the 25 included systematic reviews. As such, the literature search for primary literature was not altered following selection of the systematic review into the evidence base. Instead, where overlap was recognized between studies included in the identified systematic reviews and identified primary studies, primary studies were either removed from the evidence base, or when primary literature reported on additional outcomes, overlapping outcomes were not extracted in the primary literature. This methodology ensured that data were not included twice in the evidence base, as this could result in an overestimate of effect. A total of 809 primary literature studies were identified that met the inclusion criteria. An updated search was conducted from March 2024 through May 2025 which captured an additional 114 new studies.

Data Abstraction

Data were extracted from all studies that passed full-text review by an independent methodologist.

Risk of Bias Assessment

Individual Study Quality and Potential for Bias

Quality assessment for all retained studies was conducted. Using this method, studies deemed to be of low quality would not be excluded from the systematic review, but would be retained, and their methodological strengths and weaknesses discussed where relevant. To define an overall study quality rating for each included study, risk of bias as determined by validated study-type specific tools, was paired with additional important quality features. To evaluate the risk of bias within the identified studies, the Assessment of Multiple Systematic Reviews 2 (AMSTAR 2)[9] tool was used for systematic reviews, the Cochrane Risk of Bias Tool 2[10] was used for randomized studies, and a Risk of Bias in Non-Randomized Studies – of Intervention (ROBINS-I)[11] was used for observational studies. Additional important quality features, such as study design, comparison type, power of statistical analysis, and sources of funding were extracted for each study.

Data Synthesis

Review Manager version 5.4[12] was used to perform meta-analysis and generate forest plots when data were homogeneous and poolable using a random-effects model. For dichotomous outcomes (stone-free rate, stone clearance rate, complication rate, rate of surgical intervention, rate of emergency department visits), risk ratios were calculated using the Mantel-Haenszel method (M-H), while for continuous outcomes (pain episodes, pain medication dosage), mean differences (MD) were calculated using an inverse variance method. Statistical heterogeneity was assessed using the Higgins I^2 value and the chi square test. A Higgins' I^2 value >50% and p-values <0.05 were considered to represent significant heterogeneity. Causes of heterogeneity were explored by subgroup analysis. Subgroup analyses were also conducted for stone size and stone locations when appropriate.

Determination of Evidence Strength

The Grading of Recommendations Assessment, Development, and Evaluation (GRADE)[13] system was used to determine the aggregate evidence quality for each outcome, or group of related outcomes, informing Key Questions. GRADE defines a body of evidence in relation to how confident guideline developers can be that the estimate of effects as reported by that body of evidence, is correct. Evidence is categorized as high, moderate, low, and very low, and assessment is based on the aggregate risk of bias for the evidence base, plus limitations introduced as a consequence of inconsistency, indirectness, imprecision, and publication bias across the studies.[14] Additionally, certainty of evidence can be downgraded if confounding across the studies has resulted in the potential for the evidence base to overestimate the effect. Upgrading of evidence is possible if the body of evidence indicates a large effect or if confounding would suggest either spurious effects or would reduce the demonstrated effect.

The AUA employs a 3-tiered strength of evidence system to underpin evidence-based guideline statements. **Table 1** summarizes the GRADE categories, definitions, and how these categories translate to the AUA strength of evidence categories. In short, high certainty by GRADE translates to AUA A-category strength of evidence, moderate to B, and both low and very low to C.

The AUA categorizes body of evidence strength as Grade A, Grade B, or Grade C. By definition, Grade A evidence is evidence about which the Panel has a high level of certainty, Grade B evidence is evidence about which the Panel has a moderate level of certainty, and Grade C evidence is evidence about which the Panel has a low level of certainty.[15]

TABLE 1: Strength of Evidence Definitions

AUA Strength of Evidence Category	GRADE Certainty Rating	Definition
A	High	• Very confident that the true effect lies close to that of the estimate of the effect
B	Moderate	• Moderately confident in the effect estimate • The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
C	Low Very Low	• Confidence in the effect estimate is limited • The true effect may be substantially different from the estimate of the effect • Very little confidence in the effect estimate • The true effect is likely to be substantially different from the estimate of effect

AUA Nomenclature: Linking Statement Type to Evidence Strength

The AUA nomenclature system explicitly links statement type to body of evidence strength, level of certainty, magnitude of benefit or risk/burdens, and the Panel's judgment regarding the balance between benefits and risks/burdens (**Table 2**). Strong Recommendations are directive statements that an action should (benefits outweigh risks/burdens) or should not (risks/burdens outweigh benefits) be undertaken because net benefit or net harm is substantial. Moderate Recommendations are directive statements that an action should (benefits outweigh risks/burdens) or should not (risks/burdens outweigh benefits) be undertaken because net benefit or net harm is moderate. Conditional Recommendations are non-directive statements used when the evidence indicates that there is no apparent net benefit or harm, or when the balance between benefits and risks/burden is unclear. All three statement types may be supported by any body of evidence strength grade. Body of evidence strength Grade A in support of a Strong or Moderate Recommendation indicates that the statement can be applied to most patients in most circumstances and future research is unlikely to change confidence. Body of evidence strength Grade B in support of a Strong or Moderate Recommendation indicates that the statement can be applied to most patients in most circumstances, but better evidence could change confidence. Body of evidence strength Grade C in support of a Strong or Moderate Recommendation indicates that the statement can be applied to most patients in most circumstances, but better evidence is likely to change confidence. Conditional Recommendations also can be supported by any evidence strength. When body of evidence strength is Grade A, the statement indicates that benefits and risks/burdens appear balanced, the best action depends on patient circumstances, and future research is unlikely to change confidence. When body of evidence strength Grade B is used, benefits and risks/burdens appear balanced, the best action also depends on individual patient circumstances and better evidence could change confidence. When body of evidence strength Grade C is used, there is uncertainty regarding the balance between benefits and risks/burdens, alternative strategies may be equally reasonable, and better evidence is likely to change confidence.

Where gaps in the evidence existed, the Panel provides guidance in the form of Clinical Principles or Expert Opinions with consensus achieved using a modified Delphi technique if differences in opinion emerged.[16] A

Clinical Principle is a statement about a component of clinical care that is widely agreed upon by urologists or other clinicians for which there may or may not be evidence in the medical literature. Expert Opinion refers to a statement, achieved by consensus of the Panel, that is based on members' clinical training, experience, knowledge, and judgment.

TABLE 2: AUA Nomenclature Linking Statement Type to Level of Certainty, Magnitude of Benefit or Risk/Burden, and Body of Evidence Strength

Evidence Grade	Evidence Strength A (High Certainty)	Evidence Strength B (Moderate Certainty)	Evidence Strength C (Low Certainty)
Strong Recommendation (Net benefit or harm substantial)	-Benefits > Risks/Burdens (or vice versa) -Net benefit (or net harm) is substantial -Applies to most patients in most circumstances and future research is unlikely to change confidence	-Benefits > Risks/Burdens (or vice versa) -Net benefit (or net harm) is substantial -Applies to most patients in most circumstances but better evidence could change confidence	-Benefits > Risks/Burdens (or vice versa) -Net benefit (or net harm) appears substantial -Applies to most patients in most circumstances but better evidence is likely to change confidence (rarely used to support a Strong Recommendation)
Moderate Recommendation (Net benefit or harm moderate)	-Benefits > Risks/Burdens (or vice versa) -Net benefit (or net harm) is moderate -Applies to most patients in most circumstances and future research is unlikely to change confidence	-Benefits > Risks/Burdens (or vice versa) -Net benefit (or net harm) is moderate -Applies to most patients in most circumstances but better evidence could change confidence	-Benefits > Risks/Burdens (or vice versa) -Net benefit (or net harm) appears moderate -Applies to most patients in most circumstances but better evidence is likely to change confidence
Conditional Recommendation (Net benefit or harm comparable to other options)	-Benefits = Risks/Burdens -Best action depends on individual patient circumstances -Future Research is unlikely to change confidence	-Benefits = Risks/Burdens -Best action appears to depend on individual patient circumstances -Better evidence could change confidence	-Balance between Benefits & Risks/Burdens unclear -Net benefit (or net harm) comparable to other options -Alternative strategies may be equally reasonable -Better evidence likely to change confidence
Clinical Principle	a statement about a component of clinical care that is widely agreed upon by urologists or other clinicians for which there may or may not be evidence in the medical literature		
Expert Opinion	a statement, achieved by consensus of the Panel, that is based on members' clinical training, experience, knowledge, and judgment for which there may or may not be evidence in the medical literature		

Peer Review and Document Approval

An integral part of the guideline development process at the AUA is external peer review. The AUA conducted a thorough peer review process to ensure that the document was reviewed by experts who were knowledgeable in the area of urinary stone disease. In addition to reviewers from the AUA PGC, Science and Quality Council (SQC), and Board of Directors (BOD), the document was reviewed by external content experts. Additionally, a call for reviewers was placed on the AUA website from April 23, 2025 to May 7, 2025 to allow any additional interested parties to request a copy of the document for review. Additional notifications were sent through various AUA membership and patient advocacy channels to further promote the availability of the document for review. The draft Guideline was distributed to 225 peer reviewers. All peer review comments were blinded and sent to the Panel for review. In total, 148 reviewers provided comments. At the end of the peer review process, a total of 1,596 comments were received. Following comment discussion, the Panel revised the draft as needed. Once finalized, the Guideline was submitted to the AUA PGC, SQC, and BOD for final approval.

GUIDELINE STATEMENTS

PRE-OPERATIVE EVALUATION AND PREPARATION

1. **For adult and pediatric patients undergoing surgical intervention for kidney and/or ureteral stones, clinicians should obtain a medical history, perform a relevant physical examination, and obtain laboratory studies appropriate to procedural risk and patient comorbidities. (*Clinical Principle*)**

   The Panel recommends a focused medical history and physical examination in patients undergoing upper urinary tract stone surgery. Relevant medical history should include prior symptomatic kidney stone episodes, prior stone analyses, stone surgery, urinary tract reconstructive surgery, UTIs, medical co-morbidities including kidney and cardiopulmonary disease, functional status, and medication use, including anticoagulation (AC, including vitamin K antagonists, direct oral anticoagulants, and heparin) and AP therapy and herbal and dietary supplements known to increase bleeding risk (https://www.auanet.org/guidelines-and-quality/quality-and-measurement/quality-improvement/clinical-consensus-statement-and-quality-improvement-issue-brief-(ccs-and-qiib)/optimizing-outcomes-in-urological-surgery-pre-operative-care-for-the-patient-undergoing-urologic-surgery-or-procedure). Relevant exam components should include an assessment of general health and functional status, including vital signs and determination of body mass index (BMI). It may also include an examination of the flank, abdomen, genitourinary, and cardiopulmonary systems. Physical examination should also include an assessment of patient body habitus to identify any physical limitations that might preclude or require modification of appropriate positioning for the planned procedure.

   In the absence of RCTs to determine laboratory studies that should be routinely obtained during the pre-operative evaluation prior to surgical intervention for upper urinary tract stones, the Panel recommends using procedural risk and medical history to select the most appropriate tests. Consistent with the American Society of Anesthesiologists Practice Advisory for Pre-anesthesia Evaluation, routine hemoglobin is not automatically required; it should be ordered when the procedure is invasive or when anemia, coagulopathy, or other bleeding risk is known or suspected. Similarly, assessment of serum chemistries should be considered for patients with known or at risk for renal insufficiency.[17] The Panel concurs with patient-specific laboratory assessment, underscoring that in patients with anemia or renal insufficiency, assessment of pre-operative hemoglobin and renal function is particularly relevant. In selected patients who may require additional expertise in pre- and perioperative planning, consultation with relevant specialties (e.g., cardiology, hematology, anesthesiology) should be considered.

   In patients undergoing SWL or PCNL, the Panel recommends obtaining a coagulation panel in patients with known bleeding diatheses or prior episodes of abnormal bleeding (e.g., abnormal bleeding during tooth extraction). The Society of

Interventional Radiology recommends three primary criteria to determine whether to discontinue AC/AP therapy: 1) whether the procedure may be performed on AC 2) whether the procedure is emergent 3) whether the patient is at elevated thrombotic risk.[18] The Society also considers percutaneous nephrostomy (PCN) tube placement to be a high bleeding risk procedure and recommends a screening coagulation panel, platelet count, and hemoglobin, and correction of abnormal parameters.[18] In contrast, some studies in the urologic literature have suggested that routine coagulation studies before PCNL may not be necessary.[19]

The Panel recommends that prior to surgery, in particular PCNL, clinicians should obtain or review laboratory studies relevant to procedural and patient bleeding risk. The Panel concurs with the AUA Clinical Consensus Statement on Anticoagulation and Antiplatelet Therapy in Urologic Practice that AC/AP therapy may be safely reversed in the perioperative period for all stone procedures (https://www.auanet.org/guidelines-and-quality/quality-and-measurement/quality-improvement/clinical-consensus-statement-and-quality-improvement-issue-brief-(ccs-and-qiib)/anticoagulation-and-antiplatelet-therapy), in conjunction with risk assessment by medical teams such as cardiovascular medicine specialists.

2. **For adult and pediatric patients with kidney and/or ureteral stones, clinicians should obtain a urinalysis and/or urine culture prior to surgical intervention. (*Clinical Principle*)**

Obtaining urine testing prior to urological intervention supports safe surgical outcomes and informs timely antimicrobial therapy before, during, and/or following stone surgery. The Panel recommends urinalysis prior to surgery for upper urinary tract stones, including PCNL, URS, and SWL. While a negative urinalysis alone may be sufficient to predict a low risk of infectious complications after URS[20], urine culture should be performed when urinalysis suggests that infection may be present. Urine culture should be considered for patients with clinical conditions and risk factors that confer higher infectious risk, such as urinary tract obstruction, recurrent UTI, history of obstructive sepsis or septic shock, bacterial or fungal colonization, history of struvite (magnesium ammonium phosphate) stones, diabetes, immunocompromised state, chronic steroid use, and chronic indwelling drainage tubes. [21, 22] The Panel recommends obtaining urine culture prior to PCNL due to the increased risk of direct vascular exposure to urine during manipulation of the urinary tract, thereby increasing the risk of infectious complications. While no specific time threshold for urine testing prior to surgery has been established, the Panel recommends that clinicians use clinical judgment and patient risk factors (noted above) to determine optimal timing of testing.

Urinalysis and/or urine culture results should be used to aid in the selection of antimicrobial therapy. If testing demonstrates positive urine culture or bacterial growth, clinicians should prescribe culture-directed therapy to attempt to sterilize the urine prior to surgery.[23] Antimicrobial therapy should also be considered in asymptomatic patients with known colonization. The optimal duration of antimicrobial therapy prior to upper urinary tract stone surgery has not been established, but studies of pre-operative prophylactic antibiotics for PCNL have suggested 7 days in moderate- to high-risk patients.[24] Confirmation of a negative culture following culture-directed antimicrobial therapy is not routinely necessary[25] and may prove impossible, particularly in patients with infection stones. Molecular tests such as polymerase chain reaction (PCR) are not yet widely used or studied for minimizing infectious risk after stone surgery.

Newer molecular-based methods of diagnosing bacteriuria and identifying antimicrobial susceptibilities, including next-generation sequencing (NGS) and PCR, have shown superior sensitivity in detecting bacteria in urine compared to conventional urine culture.[26] However, these molecular-based techniques cannot distinguish between actively multiplying bacteria and dead or quiescent organisms, which can limit the applicability of these techniques. Additionally, detection of genetic antimicrobial sensitivity may not necessarily imply phenotypic antimicrobial sensitivity as determined by microbiologic testing. Finally, few studies have compared actual patient outcomes as a result of initiation of antibiotics based on PCR/NGS testing versus standard urine culture. Consequently, the use of molecular-based testing to guide antimicrobial therapy should be considered with caution.[27]

3. **For adult and pediatric patients with kidney and/or ureteral stones and untreated bacteriuria/funguria, clinicians should not proceed with definitive stone surgery. (*Clinical Principle*)**

If a properly obtained urine culture prior to surgical treatment for upper tract stones reveals bacterial or fungal growth, the Panel recommends treatment with appropriate culture-specific antibiotics or antifungals prior to surgery, even if the patient is asymptomatic. In the face of surgical manipulation of the urinary tract, particularly with the use of high-pressure irrigation during endoscopic procedures, untreated bacteriuria or funguria poses a risk of sepsis. Although classically a clinically significant "UTI" requires a urine culture demonstrating a bacterial colony count of $>10^5$, the colony count threshold that is associated with an increased risk of sepsis during surgery for stones is unknown, and even low colony counts may warrant a course of antimicrobial therapy, depending on the situation.

The optimal duration of antimicrobial therapy for a positive urine culture prior to intervention for stones has not been firmly established. Patel et al. randomized 80 patients with positive urine cultures undergoing PCNL to either two days of culture-specific intravenous antibiotics or to seven days of culture-specific oral antibiotics followed by demonstration of a negative urine culture and administration of a dose of intravenous antibiotics, prior to PCNL.[28] They found no difference in rates of systemic inflammatory response syndrome (SIRS) or septic shock between the groups, suggesting that both regimens may be equally effective. On the other hand, Sur et al. randomized 123 high risk patients (positive urine culture or indwelling tubes) undergoing PCNL to 2 versus 7 days of pre-operative oral or intravenous antibiotics and found a higher risk of sepsis in the 2-day group than in the 7-day antibiotic group (odds ratio [OR]: 3.1; 95% CI: 1.1 to 8.9; p=0.031). Further RCTs with adequate sample sizes and assessment of other surgical treatment modalities will be necessary before a clearly defined duration of pre-operative antibiotic therapy for patients with positive pre-operative urine cultures can be determined.[24]

Although confirmation of a negative urine culture after treatment of documented bacteriuria prior to stone surgery may be ideal, it is not always possible to sterilize the urine of patients with infection-related or chronically obstructing stones, and a repeat urine culture may not be necessary after an appropriate course of treatment. Of note, relief of chronic obstruction prior to surgery may allow more effective eradication of bacteriuria and is left to the discretion of the surgeon.

4. **For adult patients with kidney and/or ureteral stones, clinicians may obtain cross-sectional imaging to guide surgical treatment selection. (*Conditional Recommendation; Evidence Level: Grade C*)**

Accurate assessment of stone characteristics and urinary tract anatomy is essential for determining the most effective and least invasive surgical approach. Non-contrast abdominopelvic CT is the most reliable imaging modality for evaluating stone size and volume, location, number, and density, all of which directly influence the success rates and appropriateness of stone procedures. CT also allows assessment of anatomic variations, relational anatomy of the kidney, intrarenal geometry including infundibular angle, hydronephrosis, the presence of distal obstruction, and patient factors such as body habitus and stone-to-skin distance that may affect procedural choice and outcomes.

Multiple studies have demonstrated the advantages of CT in selecting patients for SWL because CT parameters can predict treatment outcomes. A meta-analysis of 7,869 SWL patients who underwent pre-operative CT showed that higher skin-to-stone distance, stone size, and stone density, which are characteristics most accurately assessed on CT, were associated with lower post-operative stone-free rates.[29] Additional cohort studies have confirmed the impact of skin-to-stone distance, stone size, and stone density on residual fragments and stone-free rate.[30-41] CT window may impact the accuracy of stone size measurements.[42] Renal stone attenuation ≤1000 Hounsfield units (HU), skin-to-stone distance ≤10 cm, and stone size ≤10 mm can optimize successful outcomes after SWL. When these parameters are not favorable, URS or PCNL may be more effective treatment options and can accommodate patients with longer skin-to-stone distance, large or multifocal stone burden, and higher stone density.

In patients with complex anatomy and appropriate glomerular filtration rate, contrast-enhanced CT urography can provide additional detail about renal morphology, geometry of the collecting system, and renal function. Excretory phase imaging can delineate the presence of infundibular stenosis, calyceal diverticula, and ureteral stricture that may influence procedural choice and success. Prone imaging may provide a reliable representation of the relational anatomy of the kidney if prone PCNL is planned. Alternatively, retrograde pyelography may provide some detail about anatomy of the ureter and renal collecting system in select cases.

Where available, CT-based volumetric measurement may be obtained with validated 3-D segmentation software or artificial-intelligence (AI) algorithms. Stone volume may assess true stone burden more comprehensively and can predict operative time and treatment outcomes more accurately compared with conventional linear measurements.[42-51]

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 risks of ionizing radiation exposure in pediatric patients should be weighed against the benefits of detailed anatomic information that CT may provide. On the one hand, pediatric patients may be more vulnerable to long-term radiation-induced injury due to their longer expected lifespan. However, low-dose CT protocols can typically provide similar detailed anatomic information most relevant to treatment selection compared to standard-dose CT in adults and may be expected to perform similarly in pediatric patients.[52, 53]

Compared to CT, MRI and US may provide some relational and intrarenal anatomic detail that can guide treatment selection. However, neither MRI nor US reliably measures stone density and MRI does not reliably visualize upper urinary tract stones. In addition, US estimates stone size, number, and location less accurately than CT. These factors may limit the utility of these non-CT modalities in informing suitability for SWL in particular.[54] When possible, US imaging should be performed by clinicians with advanced training and/or experience with this imaging modality to achieve the highest accuracy for pre-operative assessment.[55, 56]

5. **For adult patients undergoing PCNL for kidney and/or ureteral stones, clinicians should obtain a CT prior to surgery. (*Moderate Recommendation; Evidence Level: Grade C*)**

In patients undergoing PCNL for kidney and/or ureteral stones, non-contrast abdominopelvic CT provides detailed anatomic information that is important for surgical planning, including stone size, location, number and burden, and density, as well as renal anatomy, collecting system anatomy, the presence of anatomic variants such as horseshoe kidney or retrorenal colon and spleen. CT can also identify the presence of complicating factors, including hydronephrosis, ureteral obstruction, and branching or staghorn stone configuration. CT facilitates accurate assessment of stone burden and optimal sites of percutaneous renal access, including relational anatomy to adjacent organs. CT also provides useful information about skin-to-stone distance and stone volume, which impacts post-operative residual fragments, stone-free rate, and adverse events.[30, 57-60] Contrast-enhanced CT urography may be necessary to demonstrate intrarenal collecting system anatomy, including anatomic variants such as bifid and duplex systems.

The Panel supports the routine use of low-dose CT protocols to reduce exposure to ionizing radiation in all adult and pediatric patients.[55, 61, 62] However, low-dose CT may provide inadequate or inaccurate detail in certain situations. In patients with morbid obesity or large body habitus, low-dose CT may produce noisy or grainy images which limit diagnostic accuracy. Low-dose CT is feasible in patients with a BMI between 25 and 35 using iterative image reconstruction algorithms.[63] In patients with complex or reconstructed renal anatomy, low-dose CT may not provide sufficient detail for access planning or permit 3-D image reconstruction that may be useful in surgical planning.[64] Clinicians may consider standard-dose non-contrast CT or contrast-enhanced CT urography in these situations.

Although the systematic review for this Guideline did not capture any relevant evidence in pediatric patients to support this recommendation, the Panel supports the use of low-dose CT protocols in pediatric patients. The risks of ionizing radiation exposure should be weighed against the benefits of detailed anatomic information that CT may provide, especially for pediatric patients undergoing PCNL (**see Guideline Statement 4**).

Other imaging modalities that provide cross-sectional detail such as MRI and US, may provide some or most of the information for adequate surgical planning prior to PCNL. However, CT provides this information most comprehensively compared to other modalities. Clinicians should prioritize adequate clinical and anatomic information to enable safe, effective PCNL when deciding whether to obtain dedicated CT imaging. Patients who have undergone recent cross-sectional imaging for other purposes that contain sufficient detail for surgical planning may not require additional dedicated imaging prior to surgery.

6. **For adult and pediatric patients undergoing surgical intervention, clinicians should assess differential renal function if there is suspicion of clinically relevant loss of renal function in the involved kidney. (*Expert Opinion*)**

Upper urinary tract stone disease may contribute to renal functional loss due to chronic obstruction or infection or from complications of stone surgery such as stricture. Clinicians may suspect functional loss based on clinical history, such as history of chronic obstruction; laboratory studies, such as estimated glomerular filtration rate suggesting chronic kidney disease; or imaging findings, such as severe hydronephrosis, parenchymal volume loss, cortical thinning, or contralateral compensatory renal hypertrophy.[65-67] Determination of differential function using functional imaging (e.g., mercaptoacetyltriglycine [MAG-3] nuclear renogram or dimercaptosuccinic acid [DMSA] scan) may help clinicians determine whether surgical stone removal is indicated or if an alternative management strategy, such as nephrectomy or observation, would be preferred. Because radiotracer uptake and excretion may be impaired in cases of chronic obstruction, renal decompression with a ureteral stent or nephrostomy tube may be considered prior to determining the salvageability of the renal unit. The degree of salvageability may vary by patient and age. Thus, clinicians should use clinical judgement when incorporating these findings into treatment selection.

TREATMENT OF PATIENTS WITH URETERAL STONES

7. **For adult and pediatric patients with ≤10 mm distal ureteral stones, clinicians should offer MET with alpha-adrenergic blockers for approximately 30 days to facilitate stone passage. (*Strong Recommendation; Evidence Level: Grade A*)**

For patients who elect a trial of spontaneous passage for a ≤10 mm distal ureteral stone, initiation of pharmacotherapy with any alpha-adrenergic blocker (i.e., tamsulosin, alfuzosin, doxazosin, terazosin, and silodosin) has been shown to increase the likelihood of spontaneous stone passage, reduce associated pain, and result in fewer unplanned healthcare encounters (**Appendix 1 and 1a**). As with the initiation of any new pharmacotherapy, contraindications should be reviewed, side effects should be discussed, and the patients counseled that this indication is off label.

For the purposes of this Guideline, a meta-analysis was performed comparing outcomes of patients with ≤10 mm distal ureteral stones treated with any alpha-adrenergic blocker versus a control or no-treatment group that included 49 studies comprising more than 8,000 patients. It showed that use of any alpha-adrenergic blocker resulted in a statistically significantly higher rate of stone passage compared to the control group (risk ratio [RR]: 0.71; 95% confidence interval [CI]: 0.66 to 0.76), which equates to 25 more passage events per 100 persons than in the control group (**Appendix 1a**). In addition, MET was associated with a statistically significant reduction in pain episodes compared to placebo or no treatment (MD: -0.59; 95% CI: -0.82 to -0.37) (**Appendix 1c**). Furthermore, MET was shown to significantly reduce the need for pain medication (MD: -72.75; 95% CI: -107.87 to -37.63), the rate of unplanned healthcare encounters as measured by ED visits (RR: 0.43; 95% CI: 0.25 to 0.74), and the need for surgical intervention (RR: 0.70; 95% CI: 0.51

to 0.95) compared to the control group (**Appendix 1d, 1e, and 1f, respectively**).

Although the data included in the meta-analysis are robust across a range of studies that included a variety of pharmacological agents, different practice environments and varying patient phenotypes, there are inherent limitations, particularly with respect to stone size (i.e., <5 mm versus ≥5 to 10 mm), as very few studies stratified outcomes based on stone size.

The recommended duration of pharmacotherapy is approximately 30 days, which aligns with the duration in the included clinical trials (**Appendix 1**). In addition, in accordance with statements from the Clinical Effectiveness Protocols for Imaging in The Management of Ureteral Calculous Disease (https://www.auanet.org/guidelines-and-quality/guidelines/other-clinical-guidance/imaging-for-ureteral-calculous-disease), repeat imaging consisting of either a CT or renal US in combination with kidney, ureter, and bladder radiography (KUB) should be considered after the 30-day period of MET to assess the status of the stone.

It is common in pediatric practice to extrapolate adult evidence and apply these management principles to pediatric patients. As a result, the use of pharmacotherapy with any alpha-adrenergic blocker (i.e., tamsulosin, doxazosin, and silodosin), which is common in adults, has been increasingly utilized for pediatric patients with distal ureteral stones.[68-70] A recent meta-analysis composed of nine RCTs validated the benefit of MET in the pediatric population. It found a significantly higher rate of stone passage overall in the MET group compared to the control group (OR: 3.49; 95% CI: 2.38 to 5.12; p<0.00001), as well as for stones <5 mm (OR: 6.28; 95% CI: 1.50 to 26.29; p=0.01) and stones ≥5 to 12 mm (OR: 3.88; 95% CI: 1.29 to 11.68; p=0.02).[69] Likewise, MET was associated with fewer pain episodes (MD: -1.02; 95% CI: -1.33 to -0.72; p<0.00001) and less use of analgesics (MD: -0.92; 95% CI -1.32 to -0.53; p<0.00001) in the MET group compared to the control group.[69]

As with the initiation of any new pharmacotherapy, the contraindications should be screened, appropriate pediatric dosing applied, side effects discussed, and the patients counseled that this indication is off label. The recommended duration of pharmacotherapy is approximately 30 days, which aligns with the duration in the included clinical trials.[69] In addition, in accordance with statements from the Clinical Effectiveness Protocols for Imaging in The Management of Ureteral Calculous Disease, repeat imaging consisting of either a CT or renal US in combination with KUB should be considered after the 30-day period of MET to assess the status of the stone (https://www.auanet.org/guidelines-and-quality/guidelines/other-clinical-guidance/imaging-for-ureteral-calculous-disease).

8. **For adult patients with ≤10 mm stones in the middle and proximal ureter, clinicians may offer MET with alpha-adrenergic blockers for approximately 30 days to facilitate stone passage. (*Conditional Recommendation; Evidence Level: Grade B*)**

In a meta-analysis prepared for this Guideline, which included 4 studies totaling nearly 200 patients with stones ≤10 mm in the middle ureter and 6 studies encompassing nearly 650 patients with stones ≤10 mm in the proximal ureter, no significant difference in rates of spontaneous stone expulsion was found between the MET and control groups (middle ureter: 0.88, 95% CI: 0.50 to 1.55; proximal ureter: 0.84, 95% CI: 0.62 to 1.13) with the addition of any alpha-adrenergic blocker (**Appendix 1b**).

However, in this meta-analysis stratified outcomes according to stone location should be interpreted with caution, as few studies specifically included or stratified outcomes by stone location, particularly in the middle ureter, but also in the proximal ureter, for additional outcomes such as need for surgical intervention, pain episodes/need for analgesics, and ED visits. Therefore, the utility of MET in patients with stones in the middle or proximal ureter is less clear. Nevertheless, the Panel concluded that despite the lack of benefit demonstrated for MET for stones in the middle and proximal ureter, the safety and success demonstrated with MET for patients with stones in the distal ureter across a range of outcomes (**Appendix 1**), make it reasonable to consider this adjuvant pharmacotherapy for ureteral stones at all locations. However, clinicians should inform patients about the limitations and uncertainties when offering MET to patients with middle or proximal ureteral stones.

Contraindications to MET agents should be reviewed, side effects should be discussed, and patients should be counseled that this indication is off label. The recommended duration of pharmacotherapy is approximately 30 days, which aligns with the duration in the included clinical trials (**Appendix 1**). In addition, in accordance with statements from the Clinical Effectiveness Protocols for Imaging in The Management of Ureteral Calculous Disease (https://www.auanet.org/guidelines-and-quality/guidelines/other-clinical-guidance/imaging-for-ureteral-calculous-disease), repeat imaging consisting of either a CT or renal US in combination with KUB should be considered after the 30-day period of MET to assess the status of the stone.

9. **When surgical treatment is indicated for adult patients with distal ureteral stones ≤10 mm, clinicians may offer URS or SWL. (*Conditional Recommendation; Evidence Level: Grade B)***

URS and SWL are the two most common surgical modalities for the treatment of patients with ureteral stones.[71] While contemporary studies comparing SWL and URS for treatment of distal ureteral stones published within the time frame of this Guideline are relatively sparse, older studies outside the designated time frame demonstrated a significantly higher stone-free rate for URS compared to SWL.[8, 72] Indeed, a meta-analysis developed for the 2016 AUA Surgical Management of Stones Guideline demonstrated a success rate of 65% for SWL versus 92% for URS for treatment of patients with distal ureteral stones.[8]

A meta-analysis performed for this Guideline compared stone-free rates for URS versus SWL. However, because one of the two included studies showed higher stone-free rates for SWL than URS with unacceptably wide confidence intervals, this analysis was considered unreliable (**Appendix 2b**). As such, the current recommendation of the Panel is to defer to prior data showing that URS has superior stone-free rates, lower re-treatment rates, and decreased need for secondary procedures compared to SWL.[8, 73] There is currently insufficient evidence to recommend URS or SWL for pediatric patients with distal ureteral stones, although both procedures are options and prospective cohort studies have demonstrated similar stone clearance.[74]

Clinicians should engage in a discussion with patients regarding additional relevant advantages and disadvantages of the two procedures, including the likelihood of requiring additional procedures, complications, anesthesia requirements, and the possible need for a ureteral stent.

10. **When surgical treatment is indicated for adult patients with <2 cm proximal ureteral stones, clinicians may offer URS or SWL. (*Conditional Recommendation; Evidence Level: Grade B*)**

A meta-analysis of RCTs comparing stone-free rates for URS versus SWL for the treatment of patients with proximal ureteral stones showed a higher stone-free rate in a single procedure with URS compared to SWL (**Appendix 2b**). Data on the specific use of semi-rigid, flexible or antegrade URS are less clear. However, contemporary comparative studies have shown no definite advantage of URS or SWL for proximal ureteral stones with regard to retreatment rates, salvage procedures, hospital length of stay, operative time, or complication rates.[75-77]

Clinicians should discuss the advantages and disadvantages of both procedures with their patients. This discussion should incorporate consideration of skin-to-stone distance, recurrent UTIs, number of stones, and stone composition. Please note that cystine stones in particular can prove resistant to fragmentation using SWL,[78] while both cystine stones and uric acid stones may be insufficiently radio-opaque for identification via fluoroscopic-guided SWL.

For all stone types, clinicians should inform patients about the risk of complications and the possibility of ureteral stent placement for each of the two procedures. Thus, patients should be informed of the possibility of stent placement after URS and that ureteral stents may be associated with post-operative pain, urinary symptoms, and infection.[79]

However, clinicians should not routinely place ureteral stents in association with SWL as it has long been established that ureteral stenting does not improve stone-free rates or the development of steinstrasse after SWL but it does increase the likelihood of lower urinary tract symptoms.[80]

11. **For adult patients with ureteral stones in whom SWL fails to result in complete stone clearance, clinicians may offer a second SWL procedure or proceed to URS. If a second SWL procedure fails, clinicians should offer URS. (*Conditional Recommendation; Evidence Level: Grade C*)**

The Panel recommends an alternative surgical modality (e.g., URS) if the initial SWL treatment results in no evidence of stone fragmentation or clearance. Furthermore, if the treated ureteral stone continues to cause obstruction after the initial treatment, consideration should be given to a modality that will relieve the obstruction in a timely fashion to avoid irreversible loss of kidney function (e.g., ureteral stent, URS, or nephrostomy tube).

A second SWL session may be offered to patients with incomplete stone clearance. However, for patients who undergo two unsuccessful sessions of SWL for treatment of a ureteral stone, an alternate treatment modality (e.g., URS) should be undertaken for the next surgical treatment. Treatment failure is defined as significant residual stone (>2 mm) within the ureter or incomplete stone clearance. A retrospective cohort study found that SWL treatment of ureteral stones (n=1593) had diminishing stone-free outcomes after two treatment sessions. Stone-free rates after the initial, second and third treatments were 68%, 46% (p=0.001; cumulative stone-free rate= 76%), and 31% (p=0.001; cumulative stone-free rate= 77%), respectively.[81] Based on an improvement in the cumulative stone-free rate from the initial treatment to the first retreatment, repeat SWL for residual fragments after the initial treatment may be a reasonable approach. However, without demonstrable improvement in cumulative stone-free rate after a second retreatment, an alternative endoscopic modality should be undertaken. In addition, a multicenter, non-inferiority RCT comparing two sessions of SWL with URS for patients with ureteral stones (n=613) found that 22.1% of patients in the SWL group and 10.3% in the URS group required a secondary procedure. The absolute risk difference between the two treatment modalities of 11.4% (95% CI: 5.0 to 17.8) fell within the 20% non-inferiority threshold, suggesting that up to 2 sessions of SWL was non-inferior to URS with regard to the need for secondary procedures.[75] While the optimal time interval between repeat SWL sessions has not been clearly defined, the 2025 European Association of Urology (EAU) Guidelines on Urolithiasis noted that repeat SWL sessions for ureteral stones are feasible within one day.[82]

12. **For adult and pediatric patients with >2 cm ureteral stones or with ureteral stones that have not been successfully treated with previous retrograde URS or SWL or are not amenable to these procedures, clinicians should offer a percutaneous antegrade approach. (*Expert Opinion*)**

For patients with medium to large or complex stone burdens, SWL and URS may have relatively low single procedure stone-free rates.[76, 83] A percutaneous approach would include PCNL, mini-PCNL or antegrade URS. Although emerging data with newly developed suction devices for URS have shown improvement in stone-free rates with suction-assisted URS compared to standard URS techniques,[84] studies directly comparing URS with suction to PCNL for the treatment of large stones are lacking. However, one RCT informing this Guideline compared mini-PCNL to URS for the treatment of >15 mm impacted proximal ureteral stones and found a higher stone-free rate for mini-PCNL over URS (96% versus 72%; p=0.035).[85] In this study, mini-PCNL was also associated with a lower rate of retreatment (6% versus 32.6%, respectively; p<0.001), but a higher incidence of bleeding complications (6% versus 0%, respectively; p>0.001). Additionally, in a recent meta-analysis comparing PCNL, URS and laparoscopic ureterolithotomy for the treatment of >10 mm proximal ureteral stones, URS was found to have a significantly lower stone-free rate than PCNL (OR: 0.28; 95% CI: 0.18 to 0.44; p<0.001), but PCNL had a longer hospital stay (weighted mean difference [WMD]: –2.57; 95% CI: -3.31 to -1.82; p<0.00001).[86]

Few contemporary studies have compared PCNL to SWL for >2 cm ureteral stones. However, the risk of post-operative obstruction from ureteral stone fragments, or steinstrasse, have been shown to increase with the size of the initial stone treated.[87]

Despite the limited data and variability of stone sizes included in the identified studies, the Panel recommends percutaneous treatment for large (>2 cm) proximal ureteral stones because of consistently higher stone-free rates for PCNL than URS or SWL for the treatment of patients with large proximal ureteral stones.

Although studies evaluating outcomes for percutaneous antegrade treatment of large stones in other locations in the ureter are lacking, the Panel recommends percutaneous antegrade treatment for stones in the middle and distal ureter if SWL or URS is unsuccessful or if retrograde ureteroscopic access or SWL is precluded by body habitus or other factors. However, stone-free rate must be weighed against the greater invasiveness of PCNL compared to SWL and URS, and clinicians should consider all relevant factors when counselling patients on treatment of these stones.

TREATMENT OF PATIENTS WITH KIDNEY STONES

13. **For adult patients with flank pain and non-obstructing kidney stones on the ipsilateral side who have no other identifiable source of pain, clinicians may offer elective surgical treatment. (*Conditional Recommendation; Evidence Level: Grade C*)**

The relationship between non-obstructing kidney stones and pain remains uncertain. Several studies have shown a reduction in pain for patients undergoing surgery for this indication.[88-90] One prospective study showed that for patients with pain, ureteroscopic removal of non-obstructing stones was associated with a decrease in pain post-operatively and an improvement in stone-related quality of life.[91] Approximately 86% of patients experienced an improvement in pain, defined as at least a 20% reduction in mean pain scores, after undergoing surgery for non-obstructing kidney stones, and 69% of patients achieved at least a 50% reduction in pain.[91] While these findings support a potential role for surgical stone removal in select patients, the available studies have limitations including single-arm designs, lack of control groups, and limited follow-up. Despite these limitations, there is no evidence to support withholding treatment in such cases. Accordingly, the Panel believes that patients with pain and non-obstructing kidney stones that would otherwise be left untreated, may be offered surgical intervention when the pain is consistent with stone-related symptoms and other causes have been reasonably excluded. Clinicians should engage in shared decision-making with patients, emphasizing the limited evidence supporting surgery in this setting and setting realistic expectations regarding potential outcomes. These include the possibility of persistent or unchanged pain after treatment, perioperative complications, and post-operative pain.

14. **For adult and pediatric patients with asymptomatic non-obstructing kidney stones, clinicians may offer either active surveillance or pre-emptive surgical intervention. (*Conditional Recommendation; Evidence Level: Grade C*)**

Asymptomatic non-obstructing kidney stones are increasingly encountered clinically, in part due to the greater use of abdominal imaging for a growing range of indications.[92, 93] The natural history of asymptomatic stones is not completely understood. Retrospective cohort studies following adult patients with asymptomatic kidney stones vary in duration of follow-up, imaging protocol, and indications for surgical intervention.[94-102] This heterogeneity in studies may account for the wide range in the reported proportion of patients experiencing spontaneous stone passage (8% to 84%) or stone growth (11% to 49%), requiring urological intervention (12% to 55%), or remaining asymptomatic (23% to 68.2%). In pediatric patients, the rate of spontaneous stone passage ranged from 53.6% to 77.8%, while the rate of stone events prompting surgical intervention ranged from 15.6% to 61.2% in 3 retrospective cohort studies.[103-105]

While larger stone size (>5 mm versus <5 mm) and stone growth of ≥1 mm/year were associated with greater likelihood of surgical intervention in two studies,[99, 100] other reports did not find an association between stone size, stone location, or stone number and the need for urological intervention. Therefore, it is challenging to counsel patients with asymptomatic stones about surgery versus observation because factors that lead to the development of stone-associated symptoms and/or of stone growth over time are not completely understood.

Two RCTs with a mean follow-up of two years compared a strategy of active surveillance versus prophylactic urological intervention in adult patients.[90, 106] Compared with active surveillance, prophylactic SWL for <15 mm asymptomatic calyceal stones did not offer any advantage with regard to stone-free rates (28% in SWL group versus 17% in the observation group; OR: 1.95; 95% CI: 0.97 to 3.89; P=0.06), quality of life, kidney function, symptoms, or hospital admissions.[90] However, observation was associated with a greater incidence of unscheduled invasive procedures.[90] An RCT in patients with small (<10 mm), asymptomatic, lower pole kidney stones found a greater likelihood of rendering patients stone-free with either SWL (90%) or URS (92%) compared with observation (10%) after 24 months.[106]

Therefore, the choice of observation versus surgical intervention requires shared decision-making and discussion with the patient regarding quality of life, risk of surgery, and patient preference. Factors that may tip the balance in favor of active surveillance include patient comorbidities such as high risk of thrombotic complications necessitating chronic anti-coagulation. Factors that may hasten the decision for urological intervention include patient occupation (e.g., pilots), development of symptoms (e.g., hematuria or infection), renal obstruction, and/or rapid rate of stone growth. An additional potential advantage of surgical intervention is the opportunity to collect stone material for composition analysis, although this should not be the only reason to proceed with a urological procedure. In patients with asymptomatic non-obstructing kidney stones in whom pre-emptive surgical intervention is elected, clinicians should choose a surgical procedure guided by stone size, number, and location, as well as kidney/ureteral anatomy and patient factors. However, in patients for whom active surveillance is elected, clinicians may offer periodic imaging studies (with frequency and modality of imaging tailored to the patient's age, stone size and aggressiveness of stone disease), and metabolic evaluation and management (as urinary supersaturation has been correlated with faster stone growth).[107, 108]

15. **For adult patients with recurrent or persistent UTIs and non-obstructing calyceal stones, clinicians may offer elective surgical stone removal for the purpose of reducing the risk of recurrent UTIs. (*Conditional Recommendation; Evidence Level: Grade C*)**

Recurrent UTIs are defined as 2 or more acute UTIs within a 6-month period, or 3 or more UTIs within a 12-month period.[109] They may occur from reinfection with a different bacterial strain or from infection with the same strain occurring more than two weeks after successful treatment of a previous UTI. Relapse (persistence) is a recurrence of the original infection with the same bacterial strain within two weeks of completing antibiotic treatment for the UTI. Non-struvite stone formers may harbor bacteria within the stone and/or biofilm on the stone, resulting in persistence.[110]

Patients with suspected struvite kidney stones, which are associated with infection and rapid stone growth, are typically managed with aggressive stone removal and are not the intended target of this Guideline statement. Rather, patients with a history of recurrent UTIs and documented or suspected non-struvite stones that are non-obstructing are the intended population. In this situation sending a stone sample for culture may help determine if the stone is the source of infection, although the clinical picture of absence of further UTIs will serve as the ultimate determinant.

Patients with recurrent UTIs and suspected non-obstructing non-struvite calyceal stones may benefit from endoscopic stone removal for the purpose of reducing recurrent UTIs. Treatment of stones with URS or PCNL has been shown to eliminate recurrent UTIs post-operatively at 1 year in 48% to 89.1% of patients.[111-113] Patients with *Escherichia coli (E. coli)* infections were more likely to experience resolution of their UTIs, while patients with *Enterococcal* infections were more likely to have persistent UTIs.[113] Patients with residual stones after treatment were also more likely to have persistent UTIs.[111, 112] A stone culture taken at the time of the procedure may aid in confirming the stone as a nidus of infection.

Shared decision-making between the clinician and the patient is encouraged to balance the risks and benefits of the procedure, especially since not all patients will be rendered infection-free by treatment of their stones. The systematic review for this Guideline did not capture any relevant evidence for pediatric patients.

16. **For adult patients undergoing SWL for kidney stones, clinicians may initiate treatment with low energy shockwaves and gradually increase the energy during the session in order to reduce the risk of bleeding complications. (*Conditional Recommendation; Evidence Level: Grade C*)**

Initiating SWL treatment at lower energy followed by an increase in energy decreases the risk of bleeding compared to initiating treatment at higher energy levels. One study reported a 24% rate of renal hematoma formation in patients treated initially at 10 kV for 1000 shocks followed by escalation to 12 kV and 14 kV compared to 44% in patients treated continuously at 14 kV (p<0.001).[114] However, there is insufficient evidence to support a specific rate, escalation strategy, or incorporation of a pause prior to escalation of energy or after a particular number of shocks with regard to bleeding complications or stone-free rates. The inability to identify a specific optimal treatment strategy derives from the finding of no differences in outcomes between treatment groups or the inability to isolate the effect of slow ramping versus a two-minute pause co-intervention in clinical trials.[114-116] No studies were identified that compared dose escalation for children undergoing SWL for kidney stones.

17. **For adult patients with <1 cm lower pole kidney stones, clinicians may offer SWL, URS, or a percutaneous approach after engaging in shared decision-making. (*Expert Opinion*)**

Sub-group analysis of a recent single-armed study evaluating the outcomes of SWL for the treatment of kidney stones found a single-procedure stone-free rate of 73.6% for <10 mm lower pole stones.[117] However, stone-free rate in this study was determined by KUB and US and included residual fragments up to 4 mm in size. The efficacy of URS and SWL for the treatment of patients with <1 cm lower pole stones has been compared in two RCTs.[118, 119] Although both studies showed higher stone-free rates for URS than SWL, the difference reached statistical significance in only one of the two trials. Sener et al. randomized 140 patients with <1 cm lower pole stones to URS or SWL and found a 100% stone-free rate in the URS arm compared with 91.5% in the SWL arm (p<0.05).[119] Of note, the URS stone-free rate represented single procedures only, while the SWL stone-free rate included a mean of 2.7 SWL sessions per patient. Furthermore, KUB and US were used to determine stone-free rates at 1 month. On the other hand, an older RCT comparing the two treatment modalities in 67 patients with ≤10 mm lower pole stones yielded stone-free rates of 50% for URS and 35% for SWL using CT imaging, a difference that did not reach statistical significance (p=0.92).[118]

Few studies have compared PCNL with SWL or URS for the treatment of <1 cm lower pole stones because of the greater morbidity of PCNL compared to the other treatment modalities. However, Albala et al. compared PCNL and SWL for the treatment of patients with ≤3 cm lower pole stones and found, in sub-group analysis, that PCNL was associated with significantly higher stone-free rates (using nephrotomography) compared to SWL for ≤1 cm lower pole stones (100% versus 63%, respectively, p=0.03).[120]

When deciding on the optimal treatment of patients with <1 cm lower pole stones, it is important to keep in mind that the goals of care for the patient should be paramount. Thus, the relevant advantages and disadvantages of each of the procedures, including invasiveness, potential complications, anesthesia requirements, likelihood of requiring additional procedures, and the possible need for ureteral stent placement should be discussed.

18. **For adult patients with >1 cm lower pole or >2 cm non-lower pole kidney stones, clinicians should not offer SWL as first-line therapy. (*Expert Opinion*)**

The studies and meta-analyses informing this statement confirmed that SWL has the lowest stone-free rate among the procedures commonly used to treat kidney stones. In addition, SWL has a significantly higher rate of retreatment and need for salvage procedures compared to URS or PCNL.[121]

URS has superior stone-free rates compared to SWL for the treatment of kidney stones.[121-123] However, standard PCNL is the treatment modality associated with the highest overall stone-free rate.[121]

The patient's goals of care should be paramount. Thus, if shared decision-making discussions with the patient reveals that stone-free rate is not the primary consideration, the relevant advantages and disadvantages of each of the potential procedures, including invasiveness, potential complications, likelihood of requiring additional procedures, and the possible need for ureteral stent placement should be reviewed. A number of studies have shown that patients often experience substantial stent-related morbidity, and some patients may prefer a procedure, such as SWL, for which stent placement is not anticipated.[124-127] Additionally, while SWL is not the ideal first-line treatment for lower pole stones >1 cm and non-lower pole stones >2 cm , there are patients who are not surgical candidates or who are at high risk for general anesthesia, for whom SWL provides a potential alternative to a chronic indwelling stent or nephrostomy tube.

Please note that decisions on surgical modality should take into consideration several parameters, including stone composition. Cystine stones in particular can prove resistant to fragmentation using SWL, while both cystine stones and uric acid stones can be insufficiently radio-opaque for identification via fluoroscopy-guided SWL.[78]

19. **For adult patients with >1 cm lower pole kidney stones, clinicians should inform the patient that PCNL is associated with a higher stone-free rate than SWL or URS. (*Strong Recommendation; Evidence Level: Grade A*)**

A meta-analysis undertaken for this Guideline comparing stone-free rates between PCNL and SWL for treatment of patients with >1 cm lower pole stones found higher stone-free rates with PCNL (**Appendix 2c**). Other additional contemporary prospective RCTs showed higher stone-free rates for standard PCNL compared to URS.[128, 129] However, because of the greater invasiveness of PCNL compared to SWL and URS, patients should be informed about the advantages and disadvantages of PCNL, including the risk of complications.

Multiple variations in PCNL technique have been introduced with the intention of reducing the morbidity of the procedure while maintaining high stone-free rates, including mini-PCNL (defined as procedures with a percutaneous sheath less than 22 Fr), micro-PCNL (sheath size 4.85 Fr) and ultra mini-PCNL (sheath size 11 Fr to 13 Fr).[130-133] Given a lack of international consensus on sheath size definition for each of these variations, the Panel has chosen the most commonly used sizes, while ensuring that the spectrum of sizes has been incorporated. The studies informing this statement revealed that, similar to standard PCNL (sheath size 24 Fr to 30 Fr), reduced tract PCNL procedures are associated with higher stone-free rates compared to SWL and URS for the treatment of lower pole stones.[134] However, the data on these reduced tract PCNL procedures have been mixed with respect to complication rates, operative time, and hospital duration compared to SWL or URS.[135, 136]

While SWL and URS continue to be treatment options for lower pole stones >1 cm, both procedures are associated with lower stone-free rates, higher retreatment rates, and greater need for salvage procedures compared to PCNL.[121, 134, 137] Clinicians should discuss the advantages and disadvantages of each procedure balanced with patient priorities for stone treatment.

20. **For adult patients with <2 cm lower pole stones undergoing URS with laser lithotripsy, clinicians should, when feasible, reposition the stone to a more superior location prior to lithotripsy. (*Moderate Recommendation; Evidence Level: Grade B*)**

Repositioning lower pole stones to a more superior location (e.g., upper pole calyx) produces higher stone clearance rates (95% and 98%) than treating stones *in situ* in a lower pole calyx (74% and 84%).[138, 139] Complications associated with repositioning are low (generally <10%) and similar to complications associated with treating the lower pole stone *in situ*. However, clinicians should avoid attempting to reposition a stone that may exceed the size of the infundibulum so as to prevent impaction of the stone and basket, leading to complications and potential need for additional surgical treatment. To that end, when repositioning a stone, clinicians should take into account the ability to release the stone from the basket or grasper and the capacity to introduce a laser through the working channel to release the stone from the basket. The use of flexible and navigable suction (FANS)-UAS and flexible ureteroscopes with integrated suction may provide an acceptable alternative to repositioning a lower pole stone, although comparative studies have not been performed.[140]

21. **For adult patients with 1 to 2 cm kidney stones, clinicians may offer mini-PCNL, when available, over URS because of higher stone-free rates. (*Conditional Recommendation; Evidence Level: Grade B*)**

In a meta-analysis prepared for this Guideline, mini-PCNL was demonstrated to have a higher stone-free rate compared to URS for the treatment of 1 to 2 cm kidney stones (**Appendix 2d**). However, the data are less clear with regard to differences in complication rates or hospital stay.[141-143] Clinicians should discuss with the patient the advantages and disadvantages of mini-PCNL, including the expected operative time.

Operative time differences for mini-PCNL versus URS for stones 1 to 2 cm have been mixed, with one study revealing increased operative time for mini-PCNL compared to URS (126 ± 41 minutes versus 56 ± 24 minutes, respectively; p<0.001), while another study showed comparable operative times (between the two treatment modalities (97 minutes versus 86 minutes, respectively; p=0.2).[85, 141]

Mini-PCNL was associated with a significantly higher stone-free rate compared with URS for stones >1.5 cm in size, as well as for stones in the lower pole and mixed locations.[141, 142, 144-147] However, for upper pole kidney stones URS was found to have a higher stone-free rate than mini-PCNL (90.4% versus 71.4%, respectively; p=0.02) in a single RCT comparing the two treatments.[147]

Although no significant difference in overall complication rates was observed between PCNL and URS, intraoperative blood loss was found to be lower with URS in an RCT.[148] URS has also been associated with less post-operative pain in two RCTs.[146, 148]

Of note, emerging data with newly developed suction devices for URS show noninferiority with regard to stone-free rates with suction-assisted URS compared to mini-PCNL.[149] There are currently insufficient high-quality studies comparing these modalities to make a definitive statement regarding efficacy.

This Guideline is not meant to imply that standard PCNL cannot be used for the treatment of stones in this size range, particularly when mini-PCNL setups are unavailable. PCNL has been shown to have significantly higher stone-free rate compared to URS, with no significant difference in complication rate, according to studies informing the evidence report prepared for this Guideline.[134] The report showed no significant difference in stone-free rate for mini-PCNL versus PCNL (including 24 Fr and 30 Fr tracts).[150] Differences in operating time, complication rates, and bleeding complications were determined to be of low certainty based on GRADE criteria. Based on these data, the Panel therefore concluded that mini-PCNL can offer similar stone-free rates to standard PCNL with potentially less patient morbidity, so should be favored by the clinician when available for renal stones in this size range.

As with other recommendations, the goals of care are paramount. Thus, the relevant advantages and disadvantages of each of the potential procedures, including invasiveness, potential complications, anesthesia requirements, likelihood of requiring additional procedures, and the possible need for ureteral stent placement should be reviewed.

22. **For adult patients with >2 cm kidney stones, clinicians should recommend PCNL as first-line therapy. (*Moderate Recommendation; Evidence Level: Grade B*)**

PCNL has been shown to have a higher stone-free rate and lower rate of retreatment in patients with large (>2 cm) stones compared to SWL and URS.[151] In particular, PCNL should constitute the first-line treatment for large, branched stones.[152] Meta-analyses performed for this Guideline comparing stone-free rates for PCNL, URS, and SWL revealed higher stone-free rates for PCNL versus SWL, and for PCNL versus URS (**Appendix 2**). A meta-analysis composed of 3 studies with 224 patients found a higher stone-free rate for PCNL compared to URS (RR: 1.61; 95% CI: 1.00 to 2.57; p=0.05) in patients with >2cm kidney stones (**Appendix 2e**). Our meta-analysis of 12 studies and 1,323 patients for all sizes and kidney locations found a significantly higher stone-free rate for PCNL over SWL (RR: 0.64; 95% CI: 0.53 to 0.76; p<0.05) (**Appendix 2c**).

In pediatric patients, a recent RCT evaluated the benefit of mini-PCNL (tract size less than 22 Fr) versus standard PCNL (24 Fr to 30 Fr tract sizes) and demonstrated comparable stone clearance.[153] Additional studies may be helpful in clarifying the role of mini-PCNL for specific stone sizes in adults and pediatric patients.

Shared decision-making discussions may reveal that a patient prefers URS to the more invasive PCNL procedure. These discussions should include the likelihood of needing multiple procedures if URS is selected instead of PCNL. Of note, there are emerging data supporting the use of suction devices for URS, that may eventually improve the efficiency of URS and result in higher single-procedure stone-free rates even for large renal stone burdens. However, at present, the data support superior stone-free rates for PCNL compared to URS.

23. **For adult patients undergoing PCNL for kidney stones up to 3 cm in size, clinicians may offer standard or mini-PCNL. (*Conditional Recommendation; Evidence Level: Grade B*)**

    Clinicians should inform these patients that mini-PCNL has stone-free rates comparable to standard PCNL but is associated with fewer complications, less pain, and shorter length of stay, but with a longer operative time. (*Moderate Recommendation; Evidence Level: Grade C*)

For patients undergoing PCNL, clinicians should counsel patients that standard (24 Fr to 30 Fr) or mini-PCNL (10 Fr to 22 Fr) offer comparable stone-free rates for stones up to 3 cm in size.[150, 154-161] For patients with stones approaching 3 cm or larger in diameter, several studies have demonstrated that standard PCNL has a higher stone-free rate.[158, 160]

The decision to perform mini-PCNL versus standard PCNL may be driven by the level of surgeon experience with each procedure, as well as access to the specialized equipment required for each of the procedures. The goal with either procedure is to efficiently break up and clear the stones with the intent of rendering the patient stone-free.

Although individual RCTs have shown comparable stone-free rates between the two procedures[156, 157, 159, 161] or favored one procedure over the other,[160, 162] two meta-analyses comparing outcomes for mini-PCNL and standard PCNL, including the treatment of patients with >2 cm stones, found comparable stone-free rates for the two procedures.[150, 154] However, while one RCT demonstrated similar stone-free rates for both procedures in patients with stones up to 3 cm in size, stone-free rates with standard PCNL were higher than with mini-PCNL for patients with 3 to 4 cm stones.[158] Taken as a whole, the stone-free rates for both procedures are comparable, and additional factors, including stone size, surgeon experience and access to equipment should factor into the decision-making process.

With regard to other outcomes, hospital length of stay was shorter for mini-PCNL compared to standard PCNL.[150, 154, 156, 157, 159, 160] This is an important consideration in terms of health care utilization and hospital bed availability. Furthermore, a meta-analysis demonstrated fewer Clavien-Dindo Grade I and II complications with mini-PCNL compared with standard PCNL, but showed similar complication rates between the two techniques for Grade III and higher complications.[154] In contrast, one RCT reported more Grade I and II complications but fewer Grade III and IV complications for mini-PCNL compared to standard PCNL.[156]

Mini-PCNL has been shown to be associated with less blood loss and lower transfusion rates compared to standard PCNL.[150, 154, 156-158, 160-162] The difference is most pronounced when mini-PCNL is compared to 30 Fr standard PCNL, but it remains significant when compared to 24 Fr PCNL as well.[150] This reduction in blood loss should be noted when counseling patients about the procedure. For patients with lower pre-operative hemoglobin levels or those who refuse blood transfusion, consideration may be given toward mini-PCNL.

Patients undergoing mini-PCNL experience less pain compared to standard PCNL.[159-161] Reducing post-operative pain may help streamline post-operative care, facilitate earlier discharge and allow for earlier return to normal activities.

One parameter that consistently favors standard PCNL is operative time, which is consistently longer for mini-PCNL compared to standard PCNL.[150, 154-156, 159-162] The smaller tract size with mini-PCNL requires the use of smaller caliber nephroscopes and instruments to fragment and clear the stone. Furthermore, a 16 Fr (5.7 mm diameter) tract requires fragmentation to smaller fragments than does a 30 Fr (10 mm diameter) tract, potentially increasing the operative time associated with reduced size tracts. The additional surgical time must be balanced against the advantages of less bleeding, shorter discharge times, and less pain experienced after mini-PCNL compared to standard PCNL. Based on review of the data, there is no clearly defined cut-point indicating the optimal stone size for mini-PCNL versus standard PCNL. Higher stone-free rates for standard PCNL over mini-PCNL for treatment of >3 cm stones have been reported and may serve as a reasonable threshold when considering mini-PCNL versus standard PCNL.[158, 160] Surgeon experience with both procedures and the availability of equipment should also factor into decision-making. The systematic review for this Guideline did not capture any relevant evidence on pediatric patients to support this recommendation.

24. **Clinicians may perform PCNL in adult patients without discontinuing daily low dose aspirin. (*Conditional Recommendation; Evidence Level: Grade C*)**

Convention has historically dictated that all AC/AP therapy should be stopped prior to PCNL. The choice for PCNL over other, less invasive procedures has generally involved the balance between higher stone-free rates and higher procedural risks, including the risk of bleeding and other complications. A systematic review and meta-analysis[163] and a more recent retrospective cohort study[164] demonstrated that the use of low dose aspirin (75 to 100 mg), an antiplatelet therapy, during PCNL is associated with no greater bleeding complications and comparable stone-free and complication rates than no aspirin use, leading this Panel to recommend that PCNL can safely be performed in patients taking low dose aspirin at the time of surgery. Falahatkar et al. studied a cohort of 603 patients undergoing PCNL, among whom 40 continued low dose aspirin therapy until the time of surgery, and found stone-free rates to be similar between those on and off of aspirin at the time of PCNL (90.9% in the no aspirin versus 97.5% in the aspirin groups; p=0.118).[165] Likewise, Otto et al. observed no increased rate of secondary procedures, regardless of stone size and location.[166] In both studies, standard sized tracts of 24 Fr or 30 Fr were used for PCNL. The systematic review and meta-analysis performed by Pan et al. analyzed 1,054 patients across 4 studies and reported on the safety of continuing low dose aspirin during PCNL.[163] The meta-analysis incorporated the Falahatkar et al. and Otto et al. cohort studies[165, 166] and found that continuing aspirin was not associated with differences in operative time, hospital duration, estimated blood loss, or complication rate,[163] which was confirmed by a recent retrospective cohort study.[164] While not directly studied for mini-PCNL, it stands to reason that mini-PCNL approaches should have similar bleeding and complication outcomes in patients who undergo PCNL while on or off aspirin therapy.

One important caveat is that PCNL performed in patients on aspirin may be associated with a longer hospital stay than PCNL in patients for whom AC was discontinued. Agrawal-Patel et al. performed a retrospective case cohort study of 325 patients who continued aspirin up until the time of PCNL and found a longer length of stay compared to those in whom aspirin was discontinued (1.9 versus 1.6 days, respectively; p=0.046). In patients for whom high dose aspirin (162 or 325 mg) was continued, the average duration of hospital stay was 3.0 ± 1.3 days compared to 2.0 ± 1.1 days (p=0.02) when aspirin was stopped prior to surgery, although other confounding factors may have come into play.[164] Rosenbluth et al. found that patients who underwent PCNL who were never on aspirin, who discontinued aspirin, or who continued aspirin during surgery, all had comparable hospital lengths of stay, averaging 1.3 to 1.4 days.[167] Consideration should therefore be given to post-operative admission for patients undergoing PCNL when they undergo surgery while on aspirin. While the evidence is equivocal as to longer hospital stays after surgery in patients taking aspirin, surgeons should exercise caution when considering same day discharge in the context of continued aspirin therapy.

25. **For adult patients undergoing PCNL for kidney stones, clinicians may administer systemic TXA at the time of PCNL to reduce blood loss, provided they have no contraindications. (*Conditional Recommendation; Evidence Level: Grade A*)**

TXA is a synthetic analog of lysine and serves as an antifibrinolytic by binding to lysine receptors of plasminogen. TXA can be administered via oral or intravenous routes. Clinicians should be aware of the contraindications, relative contraindications, and side effects of TXA. Contraindications include active thromboembolic disease (i.e., deep venous thrombosis, pulmonary embolism), history of significant risk of thromboembolic disease, and epilepsy or seizure history. This recommendation is based on a meta-analysis of RCTs performed by Prasad et al. that included 6 RCTs composed of 1,323 patients (659 in the TXA arm and 664 in the control arm) evaluating the use of TXA during PCNL.[168] Stone-free rates were higher in the TXA group compared to the control group (OR: 1.70; 95% CI: 1.23 to 2.34; p=0.001). In addition, hemoglobin drop (OR: 0.67; p=0.005) and transfusion rates (OR: 0.33; p<0.00001) were lower with the use of this drug.

A subsequent randomized double-blind placebo-controlled trial confirmed the benefits of TXA prior to PCNL (192 patients undergoing PCNL; 1 g of intravenous (IV) TXA versus placebo administered).[169] The need for blood transfusion was lower in the TXA group (2.2% versus 10.4%, respectively; RR: 0.21; 95% CI: 0.03 to 0.76;

P=0.033). In addition, stone-free rates were significantly higher with TXA compared to placebo.

The Panel recognized the strong benefit of TXA use provided by the evidence in the meta-analysis. However, there are certain limitations that will be outlined here that led to the Conditional Recommendation. The meta-analysis included patients undergoing 28 Fr and 30 Fr access; there is limited data on comparative outcomes for TXA in smaller tract sizes (e.g., mini-PCNL). The Cleveland et al. Cochrane review demonstrated no increased thrombotic event rate with TXA treatment when evaluating all six randomized controlled studies that reported on this outcome (one study demonstrated two events); however, more studies are needed given the relatively rare occurrence but the potential of critical harm.[170] The studies included different modes of TXA delivery (e.g., oral, intravenous) and at different points in the procedure (e.g., pre-operative, intraoperative, post-operative). Further studies are needed to determine optimal timing and dosing of TXA. Finally, the transfusion rate in the non-TXA group was as high as 10.4%, a rate that is considered unusually high for most institutions and surgeons.

Decisions on the use of TXA may depend on many factors, including but not limited to surgical experience (e.g., personal transfusion rates), patient factors and risks (e.g., history of thromboembolic disease), stone characteristics (e.g., need for multiple accesses), and surgical choices (e.g., tract size).

26. **For adult patients undergoing PCNL, clinicians may utilize either prone or supine positioning. (*Conditional Recommendation; Evidence Level: Grade B*)**

Although this statement specifies supine and prone positioning for PCNL, the Panel recognizes that there are other positions that have not been expressly explored in this analysis (e.g., Galdako-modified Valdivia position). RCTs comparing outcomes of PCNL with prone or supine positioning suffer from significant study heterogeneity that can produce bias. A meta-analysis by Keller et al. consisting of 12 RCTs comparing prone and supine positioning in patients undergoing PCNL found comparable stone-free rates between groups.[171] Of note, four of the RCTs in which stone-free rates were evaluated at greater than 14 days post-operatively showed higher stone-free rates in the prone group (OR: 2.15; 95% CI: 1.07 to 4.34; p=0.03). Definition of stone-free and the imaging modalities used to assess stone burden were not uniform among these 12 studies.

An additional three RCTs that were not part of the previous meta-analysis demonstrated no significant difference in stone-free rates between the prone and supine groups.[172-174] However, the definition of stone-free rate and the imaging studies used to assess this outcome differed among these trials as well. Keller et al. analyzed additional outcomes after PCNL and found a higher incidence of post-operative fever with prone PCNL (OR: 1.60; 95% CI: 1.03 to 2.47; p=0.04) and a shorter operative time (by 13 minutes) in supine versus prone PCNL (95% CI: 3.4 to 22.7; p<0.01).[171] However, no differences in complication rates, transfusion rates, blood loss, and length of hospitalization were observed between groups. For complex stones, a multicenter RCT by Perrella et al. demonstrated no difference in stone-free rates with supine or prone positioning.[174]

Surgeon experience and preference, patient body habitus/anatomy, and stone burden may influence the choice of positioning for PCNL.

27. **For adult patients undergoing PCNL for kidney stones, clinicians may utilize intraoperative US, fluoroscopy, or combination image guidance for access. (*Conditional Recommendation; Evidence Level: Grade B*)**

PCNL can be performed with either intraoperative US, fluoroscopy, or combination image-guidance for access, and three RCTs have compared outcomes among these imaging modalities.[175-177] Other modalities for access (e.g., CT-guided) were not evaluated for this analysis but are used in select patients.[178] Sahan et al. randomized 120 patients undergoing PCNL to either fluoroscopic guided access (n=60) or US-guided access (n=60). Stone-free rates were assessed at one month with non-contrast computed tomography (NCCT) using a zero residual fragment or ≤4 mm residual fragment definition for stone-free. Stone-free rates were comparable between the 2 groups (91.6% for fluoroscopy versus 93.3% for US; p=0.72), and no differences in need for additional procedures, organ injury, or transfusion rates were noted.[175]

Taguchi et al. also performed an RCT in 71 patients undergoing PCNL (36 in fluoroscopy cohort and 35 in US cohort) and found no differences in stone-free rates, organ injury, or sepsis between groups.[177]

Likewise, Zhu et al. randomized 438 patients undergoing PCNL with fluoroscopic-guided (n=145), US-guided (n=147), or combination (n=146) access and demonstrated no difference in stone-free rates, retreatment rates, bleeding complications, and rates of organ injury among the three approaches.[179]

Of note, there is a distinct paucity of studies comparing the safety and effectiveness of these three imaging approaches, and heterogeneity among the studies could introduce potential biases. Therefore, the Panel assigned this Guideline statement a Conditional Recommendation, acknowledging these limitations. The benefits of using US include reducing radiation exposure and the ability to identify the relational anatomy of the targeted kidney. Surgeon experience with the US-only approach may influence whether this should be utilized. Patient body habitus may also impact the safety and effectiveness of the US-only approach.

28. **When performing mini-PCNL in adult patients with kidney or proximal ureteral stones, clinicians may utilize a suction sheath, when available, to improve stone-free rates and reduce the need for secondary procedures. (*Conditional Recommendation; Evidence Level: Grade C*)**

Li et al. performed a meta-analysis of 4 RCTs and 3 retrospective observational studies comprising 1,803 patients undergoing mini-PCNL including 931 patients in whom a suction sheath was used and 872 patients in whom a traditional sheath was used.[180] Operative time (p<0.001) and auxiliary procedures (p<0.001) were significantly lower in the suction sheath group compared to the traditional sheath group. Furthermore, use of a suction sheath was associated with a 39% lower likelihood of requiring additional stone-removing procedures. Stone-free rates were also statistically significantly higher with utilization of a suction sheath. A meta-analysis by Chen et al. included 10 RCTs comparing PCNL with suction sheaths versus PCNL with standard sheaths. No difference in stone-free rates or sepsis rates were noted between groups, but the suction sheath group showed a statistically lower risk of blood loss, incidence rate of post-operative complications, operative time, and fevers compared with the standard sheath group.[181]

Given the heterogeneity of the studies and potential outcome bias, this statement was assigned a Conditional Recommendation. The Panel also recognized that not all surgeons have ready access to suction sheaths in their facility.

29. **For adult patients with kidney stones undergoing 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 studies by Wilhelm et al. consisting of RCTs and quasi-RCTs compared the outcomes of tubeless, totally tubeless, and standard PCNL.[182] “Tubeless” was defined as PCNL with no nephrostomy tube but with placement of a ureteral stent, “totally tubeless” indicated PCNL with no stent or nephrostomy tube, and standard PCNL involved placement of a nephrostomy tube. Only studies involving unilateral PCNL and use of single tract access were included in this analysis.

The authors found no difference in severe adverse events (Risk Ratio [RR]:1.53; CI: 0.14 to 16.46), post-operative pain scores on day one (MD: 0.56; 95% CI: 0.21 to 1.34), blood transfusions (RR: 0.64; 95% CI: 0.16 to 2.52), sepsis or fever (RR: 0.50; 95% CI: 0.05 to 4.75), and readmissions (RR: 1.0; 95% CI: 0.07 to 14.21) between the tubeless and standard approaches. However, post-operative pain scores on day one were lower in the totally tubeless group compared to the standard PCNL group (MD: -3.60; 95% CI: -4.24 to -2.96). Both tubeless and totally tubeless groups were associated with shorter hospitalization compared to the standard PCNL group.[182] Of note, all the evidence in this Cochrane review was classified as having low to moderate certainty. Three additional RCTs were published after the Cochrane systematic review. Hyder et al. compared standard PCNL to totally tubeless, noting lower analgesic use and hospital length of stay in the totally tubeless arm compared to the standard PCNL.[183] Meer et al. also compared standard to totally tubeless PCNL and reported less analgesic use, less post-operative pain, shorter hospital stay, and fewer days to return to normal activity in the totally tubeless arm.[184] Zewita et al. reported no difference in blood loss when comparing standard PCNL to tubeless PCNL.[185]

Given these data, omitting placement of a nephrostomy tube or a ureteral stent may be considered in patients. The Panel recognizes that multiple factors may determine which approach (tubeless, totally tubeless, or standard PCNL) is chosen by the surgeon, including patient renal function, risk of infectious complications, anatomical anomalies, ureteral manipulation, residual stone burden, intraoperative bleeding/complications, and need for a staged procedure. Because of the paucity of studies evaluating outcomes in these different scenarios, the Panel recommends that renal drainage decisions should be based on surgeon preference and specific patient and case considerations.

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

Several studies have reported that surgeon judgement relying on intraoperative findings and fluoroscopy during PCNL has poor sensitivity (24% to 50%) with regard to accurate assessment of the presence of residual stone fragments at the conclusion of the procedure compared to the findings of immediate/early post-operative non-contrast CT imaging.[186, 187] Moreover, surgeons commonly underestimate the size of clinically significant residual fragments,[188] which are known to confer a higher subsequent risk of re-intervention and unplanned stone events.[189-191] As such, use of CT imaging to determine the presence and location of residual stone fragments may inform the need for and planning of secondary procedures aimed at rendering the patient completely stone-free.

Immediate/early post-operative CT imaging may additionally provide screening for the presence of organ injury after PCNL. Generally, the early post-operative period may be considered to include a period within 4 weeks of the procedure. 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

31. **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. There are several approaches to reducing exposure, but the most effective means is 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 some 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. Cumulative radiation exposure from diagnostic imaging studies (e.g., CT, X-ray) as well as treatment-related exposure (e.g., fluoroscopy) should be considered as this can lead to complications such as secondary malignancies.

32. **Clinicians should inform adult and pediatric patients with kidney and/or ureteral stones that URS is associated with a higher stone-free rate than 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 adult patients with kidney and ureteral stones (**Appendix 2**).[73, 75-77, 83, 121, 192-196] One study showed that this finding held true across all stone sizes.[192] In addition, retreatment rates have been shown to be lower for URS compared to SWL.[121, 192] A meta-analysis prepared for this Guideline that comprised 24 studies and 3,934 patients comparing stone-free rates for URS and SWL, including stratified outcomes according to stone size and stone location, found an overall higher stone-free rate with URS compared to SWL (**Appendix 2f**). In addition, we performed a meta-analysis including 10 contemporary studies and 1,242 patients evaluating stone-free rates in patients with lower pole stones. The analysis demonstrated a superior stone-free rate for URS over SWL (**Appendix 2a**). One of the included studies revealed a stone-free rate of 82.1% for URS versus 61.8% for SWL.[197] Likewise, our meta-analysis comparing stone-free rate for URS versus SWL in patients with proximal stones comprised of 5 studies and 992 patients revealed higher stone-free rates for URS (**Appendix 2b**). One study demonstrated a single-procedure stone-free rate of 77.8% for URS and

38.9% for SWL.[83] Comparative outcomes for patients undergoing URS or SWL for other subcategories of stones, such as non-lower pole stones, upper pole stones or mid-ureteral stones, are sparse during the timeframe of evaluation for this Guideline. However, previous work did demonstrate single procedure stone-free rates of 91% and 82.5% for URS compared to 75% and 67% for SWL of mid-ureteral stones <10 mm and >10 mm, in size, respectively.[8] Similar findings held true for pediatric patients in one meta-analysis that showed a higher stone-free rate with URS.[198]

SWL has also been shown to have a higher rate of retreatment and greater need for auxiliary procedures than URS for stones of all sizes. An RCT revealed a retreatment rate of 47.2% and 78.4% for SWL compared to 6.1% and 17% for URS for stones <1 cm and >1cm, respectively.[195] However, length of hospital stay was shorter with SWL compared to URS for both adult and pediatric patients,[121, 198] and operating times were shorter for SWL.[198] Our analysis found no significant difference in the overall rate of complications associated with SWL versus URS.[75, 121, 194, 195] Although URS has superior stone-free rates compared to SWL, clinicians may choose to proceed with SWL after taking into account patient priorities identified during the shared decision-making process.

Stone composition should also be considered. Cystine stones in particular can prove resistant to fragmentation with SWL[78], while both cystine stones and uric acid stones may be insufficiently radio-opaque for identification via fluoroscopic-guided SWL.

33. **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 post-operative patient morbidity compared to open surgery, and the previous AUA Surgical Management of Stones Guideline recommended against the use of open, laparoscopic or robotic surgery as first-line therapy for most patients with kidney or ureteral stones.[8] A recent RCT comparing laparoscopic ureterolithotomy with URS for large impacted proximal ureteral stones revealed similar stone-free rates, confirming that a laparoscopic approach offered no real benefit in this scenario.[199] 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. Such cases also include kidney stones in patients with urinary tract anatomic abnormalities, including malrotated or pelvic kidneys, contractures, or skeletal abnormalities that prevent proper positioning for endoscopic procedures. 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.[200-202] Clinicians may also find benefit in laparoscopic/robotic stone removal for the management of patients with stones and concomitant ureteropelvic junction obstruction, or other ureteral strictures.

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

SWL is a non-invasive procedure that does not require routine use of pre-operative antibiotic prophylaxis in the absence of pre-operative evidence of UTI.[21] A meta-analysis of nine RCTs found no significant differences in the incidence of post-operative fever, positive urine culture, or clinical UTI when antibiotic prophylaxis was compared with placebo or no treatment in patients undergoing SWL without evidence of pre-operative UTI.[203] These findings were confirmed in a large retrospective cohort study of 10,809 patients in whom the use of pre-operative antibiotic prophylaxis did not impact the incidence of post-SWL UTI or sepsis.[204] When ureteral instrumentation is planned during SWL (such as insertion of ureteral stent or performance of a retrograde pyelogram), administration of pre-operative 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 pre-operative antibiotic prophylaxis is not required in pediatric patients undergoing SWL.

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

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

For patients undergoing URS, a single pre-operative, prophylactic oral or intravenous dose of an antibiotic that covers typical gram positive and negative uropathogens (chosen based on the local antibiogram) is recommended for patients without signs of infection (clinically, and by negative urinalysis or urine culture) undergoing URS for upper urinary tract stones.[21] In patients with no evidence of infection undergoing URS, a single pre-operative dose of prophylactic antibiotic significantly reduced the rate of pyuria (RR: 0.65; 95% CI: 0.51 to 0.82; p=0.0005) and bacteriuria (RR: 0.26; 95% CI: 0.12 to 0.60; p=0.001), but not of febrile UTI compared with no antibiotic use in a meta-analysis of 4 RCTs.[205] The use of an additional post-operative antibiotic dose (either routinely[206] or in select cases at the discretion of the treating urologist)[207] did not provide additional reduction in the incidence of post-URS UTI in patients already receiving a single pre-operative prophylactic antibiotic dose. However, in patients with evidence of infection (either clinically or by urine culture), a pre-operative antibiotic regimen of longer duration tailored to the local antibiotic resistance of the uropathogens lowers the incidence of UTI and sepsis,[208, 209] and is therefore indicated prior to URS. Although the systematic review for this Guideline did not capture any relevant evidence in pediatric patients to support this recommendation, the Panel recommends routine use of pre-operative antibiotic prophylaxis in pediatric patients undergoing URS.

For patients undergoing PCNL, a single pre-operative, prophylactic dose of antibiotic is recommended in low-risk patients (those with no indwelling urinary drain and with sterile pre-operative urine) to minimize the risk of infectious complications.[21] A significant proportion of patients with negative voided urine cultures before PCNL have positive kidney stone cultures, potentially contributing to incidental UTI and sepsis post-PCNL.[210] This has led to studies examining whether a longer perioperative course of oral antibiotics in addition to the single pre-operative prophylactic antibiotic provides additional protection against infectious complications post-PCNL. 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 (odds ratio [OR]: 0.284; 95% CI: 0.120 to 0.674; p=0.004), stone culture (OR: 0.351; 95% CI: 0.185 to 0.663; p=0.001), and sepsis (OR: 0.366; 95% CI: 0.234 to 0.527; p<0.001) compared to the control group.[211] In the largest study included in this meta-analysis, a 7-day course of pre-operative antibiotics was superior to a 2-day course in reducing the risk of post-PCNL sepsis in patients at moderate-high infectious risk.[24] A separate meta-analysis confirmed a lower incidence of SIRS with an extended course of perioperative antibiotics compared to a single pre-operative dose, although this reduction was primarily driven by the benefit in high-risk patients (those with either a positive pre-operative urine culture or existing indwelling urinary drainage tube) but not in low-risk patients (those with no indwelling urinary drain and negative pre-operative urine culture).[212] Additional studies confirm that in patients with low infectious risk undergoing PCNL, there is no additional benefit of a three-day course of pre-operative oral antibiotics,[213] or from extending antibiotic use beyond 24 hours post-PCNL.[214] Thus, a single pre-operative 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 chosen 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's clinical judgment and experience suggest the recommendation for routine use of pre-operative antibiotic prophylaxis is applicable to pediatric patients undergoing PCNL as well.

36. **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. Although the predictive value of urinalysis in this setting is not well established, it remains the quickest available test to help assess for UTI risk. A retrospective study of 199 patients with obstructing stones found no association between bacteria on urine microscopy and positive urine culture or systemic infection markers.[215] While imperfect, urinalysis offers timely information upon which to act whereas urine cultures, though essential for identifying causative pathogens and guiding targeted antibiotic therapy, are not typically available immediately.

White blood cell count is also important, as both leukocytosis and leukopenia have been associated with systemic infection. In certain patient populations, thrombocytopenia may also signal infection and should be considered when planning treatment. Assessment of renal function and serum chemistries, such as those included in a basic metabolic panel, are important to know in managing acutely ill patients. These values help identify renal dysfunction from obstruction and electrolyte imbalances, both of which can impact antibiotic selection and dosing. Additional optional studies include serum inflammatory markers such as C-reactive protein (CRP) and procalcitonin. Both may aid in predicting UTIs and outcomes in patients with obstructing urolithiasis, though further research is needed to establish their clinical utility.[216, 217] The Panel's clinical judgment and experience suggest the recommendation may also be applicable to pediatric patients.

37. **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 urgent renal drainage via a ureteral stent or nephrostomy tube.[218, 219] Using data from the National Inpatient Sample, Haas et al. analyzed 311,100 adults diagnosed with a UTI and either a ureteral stone or kidney stone with hydronephrosis. Mortality rates in this group differed significantly from 0.2% among non-septic patients who underwent decompression to 13.6% in patients with septic shock who did not undergo renal drainage. Multivariable analysis adjusting for age, sex, race, comorbidity, hospital region, and sepsis severity showed that delaying renal decompression by two or more days was associated with a 29% increase in the odds of death (OR: 1.29; 95% CI: 1.03 to 1.63; p=0.032).[220] 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 may be left to the discretion of the urologist in consultation with other specialists including interventional radiologists. This decision should be based on the available urologic and interventional radiology resources at the treating facility, as well as anatomic, stone, and patient specific factors. Two RCTs, including one by Lu et al. showed no significant difference in clinical outcomes between the two approaches.[218, 221] In the study by Lu et al., patients with ureteral stones meeting criteria for SIRS were randomized to receive either a nephrostomy tube (n=78) or a ureteral stent (n=72). The authors found no statistically significant differences between the two groups with regard to the incidence of post-decompression urosepsis (nephrostomy tube 15.4% versus stent 22.2%; p=0.283), time to normalization of vital signs (2.35 days versus 2.51 days; p=0.072), or hospital length of stay (7.92 days versus 8.37 days; p=0.215).[221]

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. This is likely because the obstructing stone may prevent bacteria from reaching the bladder and appearing in a midstream sample. A 2022 meta-analysis by Castellani et al. including 21 studies showed that renal pelvis cultures had the highest specificity while pre-operative midstream urine cultures were poor predictors of SIRS/sepsis after PCNL and URS.[222] In contrast, a 2024 meta-analysis by Li et al. including many of the same studies but with different analytic approach found no difference between midstream and renal pelvis cultures in predicting SIRS, and data were insufficient to draw conclusions regarding sepsis.[223] Taken together, current evidence suggests that when feasible, obtaining a urine sample proximal to the obstructing stone for culture, such as at the time of renal decompression, can yield the highest diagnostic value and offers the best opportunity to guide targeted antimicrobial therapy. Although pediatric data were not 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.

38. **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*)**

Once the need for surgical intervention with either URS or PCNL is decided, the inclusion of ipsilateral or contralateral non-obstructing kidney stones in treatment should be addressed.

One high-quality RCT[224] and an additional observational study[225] addressed this clinical scenario. 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.[224] Same-session surgical intervention resulted in a lower incidence of relapse (16% versus 63%, respectively) at a longer time interval (1632 versus 934 days, respectively) compared to observation with active surveillance. Treatment of the asymptomatic stones was associated with a small increase in operative time and no difference in the rate of post-operative complications, such as ED visits, between the two groups (13% versus 11%).[224] One limitation of the study was that the size of secondary stones was limited to ≤ 6 mm, and the median number of additional stones treated was 1.[224] Therefore, clinicians should be cautious about extrapolating this data to patients with larger or more numerous secondary ipsilateral or contralateral kidney stones.

Clinicians should also consider that additional same-session surgical therapy, particularly on the contralateral side, has a theoretical increased risk of adverse events (sum of the individual risk for each renal unit) and may require additional ureteral stent placement, which is known to have a significant impact on short-term quality of life.[226, 227] Active surveillance, rather than surgical intervention, mitigates these potential outcomes, at least for the immediate time period. However, the risk of surgical intervention must be weighed against potential morbidity of a future stone event. Active surveillance is associated with higher rates of stone growth (37% versus 8%, respectively), stone passage (29% versus 21%, respectively), unplanned healthcare encounters (29% versus 5%, respectively), and the need for delayed surgical intervention (26% versus 5%, respectively) as a result of untreated kidney stones.[224] Therefore, clinicians should take into account the potential for future stone events when counseling patients about active surveillance versus same-session surgical intervention. Furthermore, an equivalent trial does not exist in the pediatric population, and extrapolating this data to children cannot be supported.

39. **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.[228-230] 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 (OR: 2.55) and major (OR: 3.16) complications, and higher rates of retreatment (OR: 2.46).[231] Compared to staged procedures, this approach offers potential benefits including reduced total operative time and fewer anesthetic exposures. However its use should be carefully considered especially in older, high-risk populations.[232] Surgeons should be prepared to not proceed with the contralateral side if operative time is prolonged, complications occur, and/or patient condition deteriorates.

Likewise, bilateral same-session PCNL has been shown to be both effective and safe. Outcomes with regard to stone clearance, complication rates, and renal function are comparable between those undergoing bilateral versus unilateral PCNL. However, bilateral PCNL is 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.[233-235] Surgeons should be prepared to abandon the second side of a bilateral procedure if operative time on the first side is prolonged or if complications occur.

Same-session bilateral SWL has also been shown to be safe and effective when proper patient selection and procedural protocols are followed. Studies show no significant differences in renal function outcomes or the risk of bilateral renal obstruction when comparing single session to staged bilateral SWL.[236, 237] Patient comorbidities, stone burden, and anticipated operative duration should be considered when assessing procedural suitability for bilateral same-session SWL, URS, or PCNL.

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

Ureteral stents are not required after uncomplicated unilateral stone surgery. However, this does not apply to patients undergoing bilateral stone surgery or unilateral surgery in a functionally solitary kidney. This includes those patients undergoing SWL, URS, and PCNL. In such cases, omitting a stent may result in transient obstructive nephropathy caused by edema from the stone and/or surgical manipulation. To prevent this complication and prevent acute kidney injury, the Panel recommends placement of at least one 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.

41. **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*)**

Recommendations against routine ureteral stenting before SWL in prior Guidelines, including the 1997 and 2016 AUA Guidelines and the 2007 EAU/AUA Guideline for the Management of Ureteral Calculi, was based on the absence of higher stone-free rates in stented patients.[7, 8, 238] One retrospective cohort study found a higher stone-free rate in a group of unstented patients (n=1290) compared to a group of stented patients (n=303) undergoing SWL for ureteral stones (70% versus 58%, respectively; p=0.01).[81] Further support comes from a 2011 meta-analysis consisting of 8 RCTs and 876 patients that compared stented versus unstented SWL for kidney and ureteral stones. No significant difference in stone-free rate was noted between groups (RR: 0.97; 95% CI: 0.91 to 1.03; p=0.27).[80] In addition, the incidence of steinstrasse was comparable between the two groups, with the exception of one study that favored stent placement for the treatment of large kidney stones (1.5 to 3.5 cm). However, lower urinary tract symptoms were significantly higher in the stented group compared to the unstented group (RR: 4.10; 95% CI: 2.21 to 7.61; p<0.00001).[80]

Although there may be indications 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.[8]

42. **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 that included 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) compared to a higher rate of 80 spm (100% versus 92.9%; p=0.02)[239] or 120 spm (RR: 1.16; 95% CI: 1.01 to 1.34; **Appendix 3a**).[240-244] Additionally, there is some evidence that a slower rate results in less pain and fewer ED visits, with one trial reporting no ED visits after SWL at 60 spm, while 18 patients (21%) presenting to the ED after receiving SWL at 120 spm.[241] One trial in pediatric patients showed that a shockwave rate of 80 spm resulted in higher stone clearance than a shockwave rate of 120 spm in pediatric patients (90% clearance treated at 80 spm compared to 73% clearance treated at 120 spm [p=0.025]).[245] Because of the heterogeneity of treatment effect by stone location, there is no conclusive evidence that a slower shockwave strategy is more or less effective than a faster shockwave strategy for stones in the ureter versus the kidney.

43. **For adult patients undergoing SWL for kidney and/or ureteral stones, clinicians should prescribe post-operative alpha-adrenergic blockers to improve stone-free rates and reduce post-operative pain. (*Strong Recommendation; Evidence Level: Grade B*)**

A meta-analysis of 21 RCTs comprised of nearly 2,400 patients undergoing SWL demonstrated higher stone-free rates among those prescribed adjunct alpha blockers compared to those not prescribed alpha blockers (87.2% versus 76.5%, respectively; RR: 1.12, 95% CI: 1.07 to 1.16, p<0.001).[246] Accordingly, the need for salvage SWL was also lower in the alpha blocker group than in the control group (29% versus 40%, respectively).[246]

In four RCTs,[247-250] alpha blocker treatment was associated with higher stone-free rates in adult patients undergoing SWL compared to no-treatment control groups. In one RCT of 216 patients undergoing SWL, patients in the alpha blocker group had higher absolute stone-free rates (43% versus 16%, respectively; p<0.01) and stone-free plus £3 mm residual fragments rates (73.8% versus 59.6%, respectively) than the control group.[247] In another RCT involving a total of 356 patients, those prescribed adjunct alpha blockers had a 77% stone-free rate on 3-month post-operative CT compared to 48% among those not prescribed alpha blockers (p=0.002).[248] Differences were more pronounced among those with larger stones (i.e., 10 to 15 mm). There is insufficient evidence to support use of alpha blockers in pediatric patients after SWL; an RCT in pediatric patients undergoing SWL found no difference in stone-free rates in the alpha blocker group compared to the control group.[250]

The use of alpha blockers after SWL has also been shown to reduce post-operative pain. A meta-analysis of SWL trials comparing alpha blockers with no treatment/placebo revealed that patients in the alpha blocker group experienced less pain than those in the placebo/no treatment control group (8.2% versus 18.7%, respectively; RR: 0.52, 95% CI: 0.37 to 0.75, p=0.004).[246] Two other RCTs involving 283 adults undergoing SWL demonstrated lower self-reported pain with alpha blocker use.[249, 251] In one of these, the prevalence of those experiencing no pain at all was 74% with alpha blockers versus 35% without. The proportion of patients experiencing “moderate pain” (versus severe or mild) was only 2.5% with alpha blockers and 20% without alpha blockers.[249]

44. **Clinicians may perform URS for adult patients with kidney and/or ureteral stones who have uncorrected bleeding diatheses or who require continued AC/AP therapy. (*Conditional Recommendation; Evidence Level: Grade C*)**

The use of AC and AP therapy is commonly encountered in urinary stone patients requiring surgical intervention. SWL and PCNL are contraindicated in patients who cannot discontinue anticoagulation or who have an uncorrected bleeding diathesis. On the other hand, discontinuation of AC/AP therapy prior to URS depends on surgeon comfort level and patient-specific factors. However, URS offers a favorable balance of high stone-free rates, low complication rates, and wide availability, with the potential for good outcomes even in patients with uncorrected bleeding diatheses or who are taking AC/AP therapies.

While discontinuation of AC/AP therapy in the perioperative setting at the time of URS may improve intraoperative visualization, it is not clear if it affects outcomes. To address this issue, 2 cohort studies encompassing more than 16,500 URS patients examined the safety of AC/AP use. The Clinical Research Office of the Endourological Society (CROES) Ureteroscopy Global Study demonstrated that 1.1% of patients on perioperative AC/AP therapy experienced a bleeding complication compared to 0.4% of patients not on AC/AP therapy (p<0.01).[252] These data represent outcomes from multiple institutions around the world, although details regarding the severity of bleeding complications were not reported. The Michigan Urological Surgery Improvement Collaborative (MUSIC), representing multiple practice settings throughout the state of Michigan in the United States, demonstrated that while the continuation of both AP and AC increased the incidence of unplanned hospitalization, the difference was statistically significant only in patients on AP (OR: 1.48; 95% CI: 1.02 to 2.14).[253] In a single institution study specifically powered to examine the impact of bleeding-related complications in patients on AC/AP therapies during URS, bleeding complications were seen in only 1.9% of patients, and severe bleeding complications in 1.6% of patients. There was no difference in bleeding complications between patients who were or were not on AC/AP therapy.[254] In addition, pre-stenting in the setting of continuous AC/AP therapy did not appear to change composite bleeding risk for patients undergoing URS (10.3% versus 12.2%; p=0.6) although it did decrease intraoperative bleeding (0% versus 9%; p=0.04) and need for unplanned reoperation (0% versus 6.5%; p=0.02).[255]

Although some data support higher bleeding complications in patients undergoing URS while on AC/AP therapy, bleeding rates for patients both on and off AC/AP therapy during URS are nonetheless low overall. Additionally, the data demonstrate no differences in severity in bleeding complications for patients on or off AC/AP therapy. For these reasons, the Panel concluded that the data support the preferential use of URS for stone removal in patients who are unable to stop AC/AP therapy or in those with uncorrectable coagulopathies, presuming other factors do not preclude URS. Consideration can be given to pre-stenting patients in this setting.

45. **For adult patients with kidney and/or ureteral stones, clinicians may offer primary URS without prior stent placement. (*Expert Opinion*)**

A number of studies have compared complication rates and outcomes of URS in patients with pre-URS ureteral stent placement versus those treated without pre-stenting. Among 10 retrospective and 2 prospective cohort studies,[186, 187, 256-265] only 3 studies showed higher stone-free rates[186, 260, 263] and 2 studies showed lower rates of ureteral injury[187, 262] in pre-stented patients compared to patients undergoing URS without pre-placed stents. Other outcomes, including ED visits, hospital readmissions, post-operative hydronephrosis, pain, and bleeding complications were analyzed sporadically in these studies without demonstrable differences in outcomes between patients pre-stented or not prior to URS. Similarly, when a UAS was used during URS procedures, there were no differences in stone-free rates or incidence of ureteral injury between the pre-stented and not pre-stented patients.[256-259]

Without a clear directive from the literature demonstrating an advantage of pre-URS ureteral stent placement, pre-stenting is not necessary for dilation of the ureter. The Panel favors use of a pre-URS ureteral stent only in certain clinical scenarios, such as when indicated for relief of obstruction, treatment of infection, relief of pain, or improvement of kidney function, or to assure successful placement of a UAS at the time of definitive surgery. The placement of a pre-URS ureteral stent should be left to the discretion of the surgeon and based on prior knowledge of specific ureteral anatomy or stone burden, or in some pediatric patients.

46. **For adult patients with kidney and/or ureteral stones undergoing URS, clinicians may use a UAS. (*Conditional Recommendation; Evidence Level: Grade B*)**

A number of studies have examined the benefits and risks of using a traditional UAS during URS procedures. Newer surgical technologies, such as those incorporating suction or aspiration (e.g., FANS-UAS), have recently been introduced that may provide added benefit to ureteroscopic procedures but are only recently being scrutinized in randomized trials. While this statement and its supporting evidence primarily address the use of traditional (non-suction) UAS, the Panel reviewed newer data related to suction and aspiration devices (**see Statement 47**).

The use of a traditional UAS has the potential to improve the effectiveness, efficiency or safety of URS. For example, use of a UAS during URS is associated with reduced intrarenal pressure because of improved outflow.[266, 267] However, traditional UAS placement also has the potential to increase post-URS pain and complications. The literature search yielded 3 RCTs composed of 326 patients in whom stone-free rates after URS were compared between those treated with or without a UAS.[266-268] No differences in stone-free rate were found between groups in any of these studies.[266-268] Of note, stone-free rate was variably defined as completely stone-free or including ≤4 mm residual fragments according to non-contrast CT or KUB at 1 month, 1 week, or 3 days post-URS. An additional nine retrospective cohort studies corroborated the finding of no association between stone-free rate and UAS use, including studies in patients with single or multiple kidney stones, in procedures involving flexible or semi-rigid ureteroscopes and with combinations of basketing and dusting stone fragmentation strategies.[186, 256-263]

Studies comparing URS with or without UAS use have also assessed other intra-operative and post-operative outcomes. In 1 RCT in which 81 pre-stented patients were randomized to UAS use or not, no differences between groups were detected with regard to ureteral injury (low- or high-grade) or ED visits.[266] In addition, 2 other RCTs consisting of 245 unstented patients undergoing URS with or without a UAS showed no overall difference in rates of ureteral injury between the 2 groups, although need for ED visits was not assessed.[267, 268] Another study, however, found that 42% of patients in whom a UAS was used versus 35% of patients in whom no UAS was used were observed to have Grade 1 ureteral injuries, a difference that did not reach statistical significance (P=0.09).[267] Patient-reported post-operative pain has also been evaluated with respect to UAS use in an RCT using a visual analog pain scale in 81 patients (all of whom were pre-stented) undergoing URS with or without a UAS.[266] No differences in patient-reported post-operative pain were noted at 6 hours and 24 hours after surgery.

Outcomes after URS are comparable between patients treated with and without a UAS regardless of whether or not ureteral stents are in place prior to treatment. Singh et al. randomized 81 pre-stented patients to URS with or without a UAS and found no difference in stone-free rates, ureteral injuries, post-operative visual analog pain scores and ED visits between those with or without UAS.[266] Likewise, in two other RCTs[267, 268] of unstented patients undergoing URS with (n=125) or without UAS (n=120), stone-free rates and bleeding complications were comparable in the two groups, although one trial showed a slight trend toward fewer Grade 1 ureteral injuries as stated above.[267]

On the other hand, the risk of post-operative infectious complications may be reduced by use of a UAS. A 1-year, global, prospective registry of 2,239 patients undergoing flexible URS at 39 centers demonstrated no differences in stone-free rate, ureteral injury, or bleeding complications between those treated with or without a UAS.[269] However, infectious complications such as fever, urinary tract infection, and sepsis were lower among patients treated with a UAS.

Passage of a UAS is not assured in all patients, and concern for ureteral injury has deterred some practitioners from routinely utilizing UAS. While pre-placement of a ureteral stent can increase the likelihood of successful passage of a UAS, poor patient tolerance of stents often discourages routine pre-stenting prior to URS with UAS. However, a pre-operative course of alpha-blockers was shown in one retrospective study to nearly double the likelihood of successful passage of a 14/16 Fr UAS.[270] Since then, a number of RCTS and retrospective cohort studies have evaluated the benefit of pre-operative administration of a course of alpha blockers prior to URS. A recent meta-analysis comprised of 11 studies and 1,074 patients showed a reduction in the incidence of ureteral injuries (RR: 0.30; 95% CI: 0.17 to 0.53; p<0.001) with the use of pre-operative alpha blockers.[271] Although a higher likelihood of successful UAS insertion was also demonstrated with alpha blocker use (OR: 2.14; 95% CI: 1.08 to 4.23; p=0.03), overall heterogeneity and discrepancies in the sensitivity analysis cast uncertainty on this outcome. Since that meta-analysis, however, another RCT that randomized 160 patients undergoing URS to either 1 week of pre-operative tamsulosin or an identical-appearing placebo and compared the rate of successful passage of 12/14 Fr UAS found a higher rate of successful passage of a 12/14 Fr UAS in the tamsulosin group compared to the control group (88.0% versus 75.3%; p=0.038).[272] Consequently, clinicians may administer a short-course alpha blocker in advance of URS if use of a UAS is anticipated.

The use of pre-operative alpha blockers for URS was evaluated in a recent meta-analysis that assessed 15 RCTs involving 1,653 patients who underwent URS.[273] Pre-operative alpha blockers were associated with 64% lower risk of stone access failure (p<0.001), 52% lower risk of requiring ureteral dilation (p=0.002), 56% lower risk of post-operative residual stones (p<0.001), 54% lower complication risk, and shorter procedure time by 6 minutes (95% CI: -8 to -3 min; p<0.001). The only adverse event that differed between groups was a higher risk of ejaculatory dysfunction in the alpha blocker group.[273]

47. **For adult patients with kidney and/or ureteral stones undergoing URS with a UAS, clinicians may choose a flexible and navigable suction UAS.** ***(Conditional Recommendation: Evidence Level: Grade C)***

With conflicting evidence regarding the benefit of a UAS, the choice of using a UAS is left to the discretion of the surgeon and may be based on overall stone burden, anticipated length of operative time, stone fragmentation strategy (i.e., dusting versus basketing), and stone composition. However, the introduction of suction technology incorporated into deflectable UAS (FANS) introduces another variable that may impact URS outcomes. Two recent RCTs comparing URS outcomes with the use of FANS-UAS versus standard UAS both demonstrated advantages of the FANS-UAS. One multi-center RCT consisting of 320 patients undergoing URS with FANS-UAS versus traditional UAS showed higher 3-month CT stone-free rates (defined as no fragments >2 mm) (87.5% versus 70%; p<0.001), lower rates of post-operative fever (5.6% versus 17.5%; p<0.001), and greater improvement in quality of life scores in the FANS-UAS group compared with the traditional UAS group.[84] A second RCT made up of 132 URS patients found higher stone-free rates (defined as no residual fragments >3 mm) (95% versus 67%; p<0.005) and lower visual analog pain scores (VAS) (p=0.02) in the FANS-UAS group compared to the standard UAS group.[274] Overall, among 8 studies in our systematic review (2 RCTS and 6 retrospective cohort studies)[84, 274-280] comparing FANS-UAS with standard UAS, all but one retrospective cohort study (RCS)[278] showed higher stone-free rates in the FANS-UAS group compared with standard UAS. Of note, the studies varied in their definitions of stone-free and in the length of follow-up. Because the aggregate of these studies showed a serious risk of bias, the evidence grade for this recommendation is Grade C and the recommendation is Conditional. Whether incorporating suction and deflection into UAS tips the scales in favor of UAS-use remains to be seen.

48. **Clinicians may use a single-use flexible ureteroscope or reusable flexible ureteroscope for adult patients undergoing URS for kidney and/or ureteral stones. (*Conditional Recommendation; Evidence Level: Grade A*)**

Single-use flexible ureteroscopes represent an emerging technology. In addition to their clinical effectiveness, there are health system factors (e.g., policies for purchasing new equipment) and environmental factors that are considerations in their use. In the RCTs conducted thus far, single-use ureteroscopes have been shown to be associated with higher stone clearance rates (RR: 1.08; 95% CI: 1.02 to 1.15; p=0.02) and lower rates of post-operative UTIs compared to reusable flexible ureteroscopes (RR: 0.41; 95% CI: to 0.23 to 0.72; p=0.002).[281, 282] However, there was substantial heterogeneity among the trials with regard to the definition of stone clearance. Despite the advantages of single-use ureteroscopes, external factors such as practice environment may be the primary determinant of use of single-use ureteroscopes versus reusable ureteroscopes, which remain a viable option.

49. **For adult patients undergoing URS with laser lithotripsy for kidney and/or ureteral stones, clinicians may utilize either a holmium:YAG or thulium fiber laser. (*Conditional Recommendation; Evidence Level: Grade C*)**

Complications (e.g., post-operative infection) and post-operative pain occur at similar rates after URS using either a holmium:YAG laser or thulium fiber laser (TFL).[283, 284] Furthermore, although most comparative studies have shown comparable stone-free rates with either laser, these studies are generally limited by small sample sizes that may lack the power to detect clinically meaningful differences.[284-286] An RCT conducted by Ulvik et al. found higher complete stone clearance rates for TFL lithotripsy (66%) compared to holmium:YAG laser lithotripsy (33%) for kidney stones (p=0.004).[283] However, the stone-free rates in this trial were lower than that of other studies that did not detect statistically significant differences between groups. Gauhar et al. conducted a prospective cohort study comparing strict stone clearance rates (zero residual fragments) for patients undergoing URS with TFL versus high-power holmium:YAG laser lithotripsy combined with flexible and navigable access sheaths. Stone clearance was not statistically significantly different for TFL (64.6%) or holmium:YAG (52.1%) (p=0.11).[287] Another RCT conducted by Haas et al. reported 88% and 95% complete stone clearance rates for TFL and pulse-modulated holmium:YAG laser lithotripsy, respectively, for ureteral stones.[285] Similarly, Chandramohan et al. reported comparable stone clearance between TFL and holmium:YAG laser lithotripsy for ureteral stones in any location (98% and 97%, respectively); however, the incidence of ureteral mucosal injury was 29% for TFL versus 11% for holmium:YAG.[284] For patients with ureteral stones, clinicians should consider the uncertain benefits and the potential for higher risk with TFL lithotripsy in the ureter. Thulium:YAG lasers are an emerging technology. In a prospective cohort study, Castellani et al. reported that reintervention for residual fragments was higher in the thulium:YAG group (17.2%) than the TFL group (3.1%) when combined with flexible and navigable access sheaths.[288]

50. **For adult and pediatric patients undergoing URS with laser lithotripsy for kidney and/or ureteral stones, clinicians should utilize laser settings with the lowest total power that will accomplish clinical stone ablation. (*Expert Opinion*)**

A guiding principle when utilizing URS to treat children and adults with stones in any location in the ureter and/or kidney is to use the lowest power settings necessary to ablate the stone and minimize the risk of injury. Unnecessary increases in frequency made possible by high-power lasers can increase the risk of injury due to higher delivered power that increases intra-renal temperature and laser pulses that hit the surrounding tissue rather than the stone. This principle is similar to the ALARA principle for minimizing ionizing radiation exposure from fluoroscopy during kidney stone surgery. Although the principle of using the minimum power to achieve clinical ablation of the stone applies to stones in the kidneys, particular care should be taken when performing URS with laser lithotripsy for ureteral stones, as the default power settings provided by the manufacturer have been associated with ureteral strictures. Villani et al., reported that ureteral strictures developed in 11% of patients who underwent laser lithotripsy with the thulium fiber laser using manufacturer presets compared to 1% of patients in whom individualized presets were utilized (p=0.009).[289] A guiding principle for treating ureteral stones, in particular, is to use the minimum energy required to treat the stone (e.g., <10 W), particularly when using low irrigation flow rates.

51. **For adult and pediatric patients undergoing URS with laser lithotripsy for kidney and/or ureteral stones, clinicians may utilize a strategy of fragmenting and basketing or "dusting". (*Conditional Recommendation; Evidence Level: Grade B*)**

"Dusting" is an approach to ablate stones with a laser into fine particles or "dust". A fragmentation and basketing strategy implies fracturing stones into pieces that can be individually withdrawn. A number of RCTs have compared outcomes after URS with basketing versus dusting laser strategies. A 2023 meta-analysis comparing the two strategies found a higher stone clearance rate with the basketing strategy than the dusting strategy (RR 0.6; 95% CI: 0.41 to 0.89; p=0.01 favoring basketing).[290] While operative time was 11.6 minutes shorter in the dusting group compared to the basketing group (95% CI: -19.56 to -3.63; p=0.004), retreatment rate favored basketing (RR: 2.03; 95% CI: 1.31 to 3.13; p=0.001). A more recent RCT of 60 patients undergoing URS for 5 to 30 mm proximal ureteral stones randomized patients to basketing versus dusting and found no difference in stone-free rates (86.6% versus 96.6%; p=0.3) between the two groups.[120] Of note, however, this study and all the studies included in the meta-analysis used holmium:YAG lasers, some of which were low power lasers (<50 W). Moreover, these studies in the meta-analysis were conducted before the widespread availability of suction technologies (e.g., FANS-UAS[140, 149, 277, 288, 291-302] and integrated suction ureteroscopes), which could impact outcomes. The Panel acknowledges the recent introduction of active suction during URS and its ability to facilitate stone clearance, as well as the widespread use of TFL. Further synthesis of the evidence is needed to better define the role of suction and TFL laser lithotripsy during URS and to assess their impact on the selection of laser strategy during URS.[140, 149, 277, 288, 291-302]

In pediatric patients, the basketing and dusting strategies for URS have been shown to have comparable outcomes. Stone clearance for semi-rigid URS with laser lithotripsy for pediatric patients with ureteral stones using either fragmentation/basketing or dusting is high (>96%) based on US and KUB, with no discernable differences in outcomes between the two techniques.[303]

52. **For adult patients with kidney and/or ureteral stones, clinicians may omit post-operative ureteral stent placement following uncomplicated URS. (*Conditional Recommendation; Evidence Level: Grade C*)**

Uncomplicated URS is variably defined as URS performed for patients with two functioning, anatomically normal kidneys with ureteral stone(s) that are not impacted or for kidney and/or ureteral stones for which there is no evidence of residual stone fragments and the ureter(s), in the judgement of the clinician, shows no signs of injury or significant edema. Most studies comparing outcomes of patients undergoing URS with or without post-operative stent placement involved patients undergoing URS for ureteral stones as opposed to undergoing flexible URS for kidney stones. Omitting ureteral stent placement after uncomplicated URS may result in fewer ED visits. Although four RCTs did not detect a difference in post-operative ED visits between stented and unstented patients after URS,[304-307] Allam et al. reported that 31% of patients who had a stent after URS presented to the ED compared to 22% of patients who did not have a stent, a difference that was statistically significant (p=0.048).[308] Similarly, although most trials found no differences in pain intensity between patients who underwent URS with or without post-operative stent placement,[304, 305, 307-309] Shao et al. reported that patients who did not receive a stent after URS reported less pain (3%) compared to those who received a stent (39%).[310, 311] Likewise, El Harrech et al. found that patients who underwent URS for distal ureteral stones without a stent reported less bladder and flank pain than those with a stent.[310, 311] Although Damiano et al. reported that 31% of patients developed UTI after undergoing URS for ureteral stones without ureteral stent placement compared to 21% for whom stents were placed, these procedures were performed with ballistic lithotripsy using an 8.9 Fr semi-rigid URS, and consequently these findings may not reflect contemporary practices with smaller ureteroscopes and contemporary lasers.[312] In pre-stented adult patients, stent omission post-operatively has been shown to reduce ED visits and unplanned hospitalizations.[313] Overall, omitting stent placement after uncomplicated URS does not appear to increase post-operative morbidity.

53. **For adult and pediatric patients undergoing surgical intervention for kidney and/or ureteral stones, clinicians should obtain stone for analysis when possible. *(Clinical Principle)***

Surgical collection of stone material or collection of stone fragments after SWL may provide the only opportunity to determine stone composition. In some cases, knowledge of stone composition can predict the underlying metabolic abnormalities contributing to stone formation, such as for uric acid, struvite, and cystine stones.[314, 315] Furthermore, it can impact future decisions regarding surgical stone management because of known limitations of surgical technologies with some stone types. (i.e., cystine stones are relatively SWL-resistant).[316]

54. **For adult patients undergoing surgical intervention for kidney and/or ureteral stones, clinicians should utilize a multi-modal, non-opioid analgesic regimen and minimize use of opioids for post-operative pain management. (*Moderate Recommendation; Evidence Level: Grade C*)**

Management of post-URS pain without the use of opioids is associated with fewer ED visits than with use of opioids. While the use of some non-opioid analgesics is contraindicated in some patients (e.g., NSAIDs in those with renal insufficiency), most patients requiring pain management related to stone surgery, ureteral stents, and renal colic are effectively managed with multi-modal non-opioid analgesic agents, including alpha blockers, NSAIDS, and antimuscarinics. A large retrospective cohort of 10,948 patients who underwent URS demonstrated that patients not prescribed post-operative opioids had a lower rate of unplanned ED visits within 30 days compared to those prescribed opioids (p<0.001).[317] In addition, readmission rates were lower in the group not prescribed opioids (p=0.003). In contrast, a smaller prospective cohort study involving 169 patients demonstrated no difference in ED visits among those prescribed only opioids versus those prescribed nonsteroidal anti-inflammatory drugs (NSAIDs).[318]

Opioids have not demonstrated superior pain control compared to NSAIDS after URS or PCNL. In a prospective cohort study of patients undergoing URS, those who were not prescribed opioids had no greater pain, as assessed by visual analog pain scores, in the recovery room, after discharge, or on the evening after surgery compared to those prescribed opioids ($p>0.60$ for all comparisons).[318] Indeed, overall satisfaction with pain control was higher in those not prescribed opioids (96% compared to 89% prescribed opioids), but this difference did not reach statistical significance ($p=0.40$). Likewise, a retrospective cohort study of patients who underwent PCNL demonstrated that those not prescribed adjunctive opioids and instead prescribed ketorolac showed no difference in unplanned pain-related ED visits, office phone calls, or unplanned office visits compared with those prescribed opioids ($p>0.60$ for all comparisons).[319] Finally, in an RCT among patients undergoing either PCNL or URS, patients randomized to adjunctive opioids (n=46) or ketorolac (n=44) showed comparable satisfaction with pain relief in the two groups ($p=0.70$), but self-reported average pain intensity, measured on a scale from 1 to 10, was higher in those prescribed opioids compared to those who received ketorolac (4.5 ± 2.7 versus 3.3 ± 2.6 [$P=0.04$]).[320] Based on these data, the Panel recommends non-opioid-based multimodal pain regimens as first-line therapy for patients undergoing surgical stone procedures.

55. **For adult and pediatric patients undergoing surgical intervention for kidney and/or ureteral stones, clinicians should order follow-up imaging to assess residual stone burden and to identify hydronephrosis or other procedure-related complications. (*Expert Opinion*)**

In the post-treatment setting, use of a specific imaging modality or modalities and their timing should be individualized based on patient characteristics (e.g., age, body habitus), risk factors for stone recurrence, and treatment goals. Additionally, the choice of imaging modality should be made after discussing the sensitivity, harms, and limitations of available imaging modalities to detect residual fragments.[321] If residual fragments are identified on follow-up imaging after surgical intervention, the patient can be counseled on the risk of future stone events and the benefit of secondary procedures to try to render the patient completely stone-free versus observation with active surveillance. Determining the location and amount of residual stone burden may be helpful to establish a new baseline with which subsequent surveillance imaging findings can be compared to determine the rate of stone growth and tailor preventative strategies. The optimal timing of first follow-up imaging has not been firmly established. However, initial follow-up imaging between 4 to 12 weeks after surgical intervention is a common and reasonable practice. After SWL, although KUB alone may assess residual fragments after treatment of radio-opaque stones, more commonly KUB and US are obtained after any treatment type to assess for both stone clearance and hydronephrosis. CT has the highest sensitivity and specificity for the detection of residual fragments but it subjects patients to ionizing radiation exposure.[321, 322] Low dose and ultra-low dose CT protocols can be utilized to be consistent with the ALARA principle. A prior multi-center retrospective analysis of post-URS imaging within three months showed that CT imaging had the highest frequency of detecting stone fragments associated with stone events and reintervention compared to KUB or combination KUB/US.[323] Either US or CT, but not KUB, can determine the presence of post-operative hydronephrosis. While rare, new or worsening hydronephrosis after treatment can lead to the permanent loss of renal function if the obstruction is prolonged, and therefore assessment of post-operative renal drainage is essential.[324, 325]

56. **For adult and pediatric patients with residual stones after undergoing surgical intervention for kidney and/or ureteral stones, clinicians should offer secondary endoscopic removal of residual fragments and engage in shared decision-making, taking into account the benefits and risks. (*Moderate Recommendation; Evidence Level: Grade C*)**

Any surgical intervention based on fragmentation and/or removal of urinary tract stones has the potential to leave behind residual stone fragments.

Identification of residual fragments relies on post-operative imaging, the most accurate of which is CT. The management of residual fragments and the timing of intervention have been the subject of investigation, primarily through retrospective cohort studies describing the natural history of residual fragments and stratifying outcomes according to the size of the fragments. This understanding of the natural history should then inform shared decision-making with the patient.

The decision to manage residual fragments with observation versus active intervention to remove them, depends on the balance between the risk of an additional surgical procedure versus the benefit of preventing the residual fragments from causing future pain, obstruction or infection, or continued growth that risks the need for urgent intervention. Although any residual fragment may ultimately require intervention, several studies have shown that the risk of requiring intervention is greater for larger versus smaller residual fragments. In 3 retrospective cohorts that evaluated the outcome of residual fragments after surgical stone procedures, residual fragments >4 mm in size were found to be associated with higher rates of unplanned secondary procedures than residual fragments £4 mm in size. Atis et al. reviewed 142 patients left with residual fragments after URS and found a higher rate of unplanned secondary procedures in patients with >4 mm residual fragments compared to those with £4 mm residual fragments (32.1% versus 18.6%; p=0.029).[326] Wong et al. also noted higher rates of unplanned procedures in patients with >4 mm residual fragments compared to those with £4 mm residual fragments after PCNL (43.7% versus 16.2%; p<0.001, respectively).[327] Wong et al. further demonstrated that fragments ≤2 mm were associated with a further reduction in rate of unplanned procedures to 10.3%.[327]

A 2021 meta-analysis of 18 studies including over 2,000 patients with residual stone fragments following SWL, URS, or PCNL reported that patients with residual fragments >4 mm had 50% greater odds of requiring an unplanned secondary procedure compared to patients with smaller fragments (OR: 1.50; 95% CI: 0.70 to 2.30).[328]

Although larger residual fragments are more likely to require unplanned surgical intervention, smaller fragments have been reported to be more likely to pass. Atis et al. reported that stones ≤4 mm are more likely to pass than stones >4 mm among patients with residual fragments after URS (30.23% versus 17.85%; p=0.032).[326] Although Wong et al. was unable to demonstrate a difference in stones passage rates using a 4 mm threshold, they found that stones <2 mm were significantly more likely to pass than stones >2 mm (51.9% versus 10.1%; p<0.001).[327]

Armed with this data, clinicians should counsel patients with residual fragments that these fragments may lead to asymptomatic or symptomatic stone passage or may require unplanned intervention or attention. The benefit of avoiding these events through planned secondary surgical procedures to remove residual fragments must be weighed against the risk of pre-emptive surgical intervention in a discussion with patients involving shared decision-making.

Residual fragments after PCNL represent a unique consideration due to the ability to perform a secondary procedure through an existing tract with flexible nephroscopy, which may be performed during the same admission. As recommended in **Guideline Statement 30**, for patients undergoing PCNL, clinicians may obtain a CT in the immediate/early post-operative period to assess stone-free status and determine the need for a secondary procedure. Although some residual fragments after PCNL remain asymptomatic and never require treatment, others may grow, migrate into the ureter and obstruct the kidney, cause recurrent UTIs and/or require surgical intervention. Clinicians should offer URS or flexible nephroscopy to retrieve residual fragments after PCNL. Traditionally, second look flexible nephroscopy was utilized to retrieve residual stones, but secondary URS, particularly if no nephrostomy tube is left after PCNL, is an alternative modality. URS was found to yield higher stone-free rates compared to SWL for post-PCNL residual fragments in an RCT by Xu et al. in which patients underwent treatment of post-PCNL residual fragments (n=96). URS was associated with higher stone-free rates compared to SWL at both 1 and 3 months post-operatively (84.7% versus 64.6%, p=0.022; 91.3% versus 72.9%, p=0.021, respectively).[329] In this study stone-free rate was defined as no residual fragments ≥4 mm on CT urogram at 1 and 3 months post-operatively. In addition, a retrospective cohort study found significantly higher stone-free rates (defined as 0 fragments on 90-day post-operative CT or renal US/KUB radiograph) for URS (n=36) compared to SWL (n=33) for post-PCNL residual fragments (58.3% versus 24.2%; p=0.007).[330]

The Panel acknowledges that in recent years tubeless PCNL has become more common, and recent data often do not include second look flexible nephroscopy. However, secondary flexible nephroscopy can also be used to address residual fragments. Prior studies support treating residual fragments (>2 mm) with second look nephroscopy to prevent future stone events (hazard ratio [HR]: 3.9; p=0.01).[189] Additional studies found significantly higher rates of stone-related events for residual fragments >4 mm after PCNL (p=0.039) and higher rate of residual fragment stone growth or obstruction for residual fragments >3 mm after PCNL (OR: 1.88, 95% CI: 0.919 to 3.854, p=0.05).[327, 331] The high incidence of stone-related events should encourage clinicians to at least offer a secondary procedure to treat residual fragments after PCNL.

Clinicians should engage in shared decision-making regarding the benefit of preventing a future stone event versus the risk of another surgical procedure to remove the residual fragments.

TREATMENT OF PREGNANT PATIENTS WITH KIDNEY AND/OR URETERAL STONES

57. **For pregnant patients with suspected symptomatic kidney and/or ureteral stones, clinicians should utilize US as first-line imaging. If further imaging is indicated, non-contrast MRI or CT are both appropriate alternatives. (*Expert Opinion*)**

Because US is noninvasive and has no associated ionizing radiation, it is the recommended first-line imaging modality in pregnant women with suspected obstructing stones during pregnancy.[332] If diagnostic uncertainty persists after abdominal US imaging, transvaginal US has been demonstrated to be a useful adjunct in diagnosis of distal ureteral stones, outperforming transabdominal US and detecting 94% of distal ureteral stones.[333] Additionally, Doppler US and calculation of renal resistive index (RI) may improve utility of US for diagnosing stones during pregnancy. A single center retrospective study of women with renal colic during pregnancy revealed that the mean RI of obstructed kidneys was higher than that of unobstructed kidneys (0.69 versus 0.63; p<0.0001).[334] Although there is currently no data in pregnant patients, non-visualization of the ipsilateral ureteral jet on US of the bladder may suggest obstruction.[334] However, limitations of US remain well recognized, particularly in light of the occurrence of physiologic hydronephrosis of pregnancy which may confound accurate diagnosis. In one multicenter longitudinal study, the positive predictive value (PPV) of US for the presence of a ureteral stone was 77%.[335] Therefore, additional imaging modalities may also be necessary when diagnostic uncertainty persists.

Like US, non-contrast MRI also avoids exposure to ionizing radiation and can be used during any trimester.[336] However, stones are not directly visualized on MRI, and therefore interpretation must rely on secondary findings associated with obstruction. As such, MRI has a reported 80% PPV for stones.[335]

By far, the most accurate imaging modality for the diagnosis of ureteral stones in pregnancy is non-contrast CT. Teratogenic effects of fetal radiation exposure are highest between the 2nd and 20th weeks of gestation; nevertheless, typical stone protocol CT imaging is performed at doses below teratogenic thresholds of 5 rad (50 milligray [mGy]).[337] The risk of carcinogenesis, however, does not have a threshold dose. Fetal exposure of 5 rad (50 mGy) is estimated to increase the risk of childhood cancer approximately 2-fold, from 1/2000 to 2/2000, with the highest increase in RR (3-fold) occurring during exposure in the first trimester.[337] When uncertainty persists after US imaging and a prompt diagnosis provides maternal benefit outweighing fetal risks, CT has been advocated and demonstrates diagnostic utility.[337, 338] Low dose protocols can be utilized.

When employing any imaging study during pregnancy, it is most prudent to involve the obstetric team. If ionizing radiation is to be utilized, the clinician should consider further consultation with radiology and/or a medical physicist.[337] These consultants can best inform shared decision-making with the patient.

58. **For pregnant patients with symptomatic kidney and/or ureteral stones, clinicians should coordinate pharmacologic and/or surgical intervention with the obstetrician. (*Clinical Principle*)**

Urolithiasis during pregnancy presents a myriad of challenges, including those arising from the maternal physiologic response to pregnancy, the presence of the developing fetus in utero, and potential fetal implications of exposure to medications, radiation, and anesthetics. These concerns demand a multidisciplinary approach. Obstetricians as well as radiologists, radiation physicists, anesthesiologists, and pharmacists may offer important insights into maternal and fetal risks of management. Additionally, the American College of Obstetrics and Gynecology (ACOG) issued a committee statement that when considering surgery, an obstetrician should be notified and readily available.[339]

59. **For pregnant patients with kidney and/or ureteral stones and well controlled symptoms, clinicians should offer observation with a trial of stone passage. (*Clinical Principle*)**

Successful trial of passage for ureteral stones during pregnancy has been reported, although in retrospective data, both rate of passage and time to passage varied. Utilizing strict criteria, passage rates have been reported to be as low as 48%.[340] More recent studies have reported stone passage in 40% to 60% of women, with mean time to passage between 17 and 35 days.[341] Patients should be counseled that if observation is elected, delayed intervention may be required. Intractable symptoms should prompt consideration of intervention.

The utility of tamsulosin in promoting spontaneous stone passage in pregnant women with ureteral stones has been evaluated in retrospective cohort studies.[341, 342] While two studies concluded that tamsulosin did not appear to be associated with adverse effects for either mother or unborn child, neither demonstrated significantly improved rates of passage in the tamsulosin cohort compared to the observation cohort.

60. **For pregnant patients with ureteral stones for whom a trial of passage is unsuccessful or who are not candidates for a trial of passage, clinicians may offer URS. Placement of a ureteral stent or nephrostomy tube, with frequent tube changes, may be offered as an alternative to URS. (*Conditional Recommendation; Evidence Level: Grade C*)**

For a pregnant woman with a ureteral stone who declines or experiences an unsuccessful trial of passage, the clinician may offer URS for planned definitive treatment. The safety of URS during pregnancy has been demonstrated, with published reports showing no difference in endoscopic complications compared with URS in the nonpregnant patient.[343] A 4.3% risk of obstetric complications including preterm labor has been reported, consistent with risk of obstetric complications associated with non-urologic surgery during pregnancy.[344] The American College of Obstetrics and Gynecology committee statement recommends notification of and coordination with an obstetrician and delineates perioperative and intraoperative fetal monitoring recommendations.[339]

Nonobstetric surgery during any trimester is associated with potential adverse birth outcomes. A population-based analysis identified that surgery in the third trimester compared with the first trimester is associated with increased risk of prematurity but lower risk of stillbirth.[345] The ACOG recommends that while elective surgery should be postponed until after delivery, medically necessary surgery during pregnancy should not be denied or delayed, regardless of trimester.[339] In the opinion of the Panel, the preferred timing for intervention is during the second trimester, after the period of fetal viability has been has been reached.

A decision analysis model demonstrated that compared with temporizing ureteral stent or nephrostomy tube, primary URS maximally preserved Quality-Adjusted Life Years (QALY).[346]

Although both stent and nephrostomy drainage may be considered viable alternatives to URS, growing retrospective evidence suggests advantages of stent over nephrostomy management. Compared to a nephrostomy tube, ureteral stenting was associated with lower adjusted odds ratio (aOR) for UTI (aOR: 0.52; 95% CI: 0.38 to 0.71), inpatient hospitalization (aOR: 0.4; 95% CI: 0.26 to 0.64), and ED visits (aOR: 0.65; 95% CI: 0.48 to 0.89) in a large retrospective cohort of propensity score matched administrative data.[347] Additionally, nephrostomy drainage was associated with increased odds of preterm birth compared with endoscopic options of stent placement or primary URS.[348] A single center cohort study also noted higher total radiation exposure with PCN management compared with stent or URS.[349]

Due to accelerated encrustation during pregnancy, both nephrostomy tubes and ureteral stents require more frequent stent exchange, typically every four to six weeks.[350]

FUTURE DIRECTIONS

The intensive work that went into developing this Guideline has identified much that has been accomplished in advancing our understanding of the treatment of patients with kidney and ureteral stones but has also identified gaps in knowledge. Given the prevalence of this condition, efforts to fill these gaps will result in a broader understanding of how to treat patients optimally and will meaningfully benefit urologic practice. When we look towards what should be accomplished in the coming years, so that the next iteration of this Guideline will provide even more robust guidance for the practicing urologist, there are needs both in developing and refining novel treatment approaches and how the effectiveness of these treatments will be measured.

In the Future Directions discussion of the prior Surgical Management of Stones Guideline, there was a call for an improvement in devices and technologies that can more efficiently and safely fragment and evacuate stone material.[8] In this Guideline, we now see the introduction of mini-PCNL and suction technologies. However, in many cases these technologies are still sensitive to the patient's baseline stone burden. In other cases, such as utilizing high frequency lasers for a "dusting" approach to stone treatment, the outcomes appear to be inferior to the prior technique of basket extraction. As always, future efforts should continue to be devoted to improving the efficiency of stone removal through less invasive platforms as this will continue to further benefit patients. During the drafting of this Guideline, it has been apparent that novel therapies have recently arrived or are going to be arriving in the clinical domain. Among these therapies are suction-based retrograde approaches, ultrasonic propulsion burst wave lithotripsy, robotic platforms, hybrid lasers, and the ability to monitor collecting system temperature and pressure. Importantly, as these novel technologies and techniques are introduced, they should be rigorously and critically assessed in clinical investigations that employ clearly described, high quality imaging, and adhere to standardized definitions of treatment outcomes.

As has been noted in many of the AUA Guideline documents, not just those focused on kidney and ureteral stone disease, there is a paucity of high-quality RCTs in the urologic field that compare outcomes for surgical interventions. In addition to this Guideline serving as a call for future studies of high-quality design, there is also a need to ensure that the reporting of outcomes in these studies is standardized and reproducible. In many cases, this Guideline was challenged by heterogenous reporting of not just basic factors such as stone location in the ureter, but also treatment approaches such as laser settings or lithotripter choice as well as treatment outcomes. This, unfortunately, limited the meta-analytic approach the Panel could take regarding comparative effectiveness of competing therapies. There is also a recognition that stone treatment outcomes are more nuanced than the binary outcome of stone-free/not stone-free and should include measures such as stone clearance (percent volume reduction) and residual stone burden (stone volume remaining) that can be calculated via CT imaging.

And lastly, but perhaps most importantly, understanding the patient perspective on the treatment of stones is limited, and there has been little investigation into the methodology of shared decision-making. There is a need for study designs that include patient-reported outcomes such as quality of life effects. In addition, fundamental questions that patients will ask a urologist, such as how long it will take for a ureteral stone to pass, when to intervene on an asymptomatic stone, how to optimally treat stent discomfort, and whether anything can be done to promote stone passage, remain largely unanswered. Including the patient perspective in this Guideline served to underscore these important considerations and should be front-of-mind as we design future studies assessing the quality and outcomes of stone treatment.

ABBREVIATIONS

95% CI	95% confidence interval
AC	Anticoagulant
ACOG	American College of Obstetrics and Gynecology
ALARA	As Low As Reasonably Achievable
AMSTAR 2	Assessment of Multiple Systematic Reviews 2
aOR	Adjusted odds ratio
AP	Antiplatelet
AUA	American Urological Association
AUAER	American Urological Association Education and Research, Inc.
BOD	Board of Directors
BMI	Body mass index
CROES	The Clinical Research Office of the Endourological Society
CRP	C-reactive protein
CT	Computed tomography
CUA	Canadian Urological Association
DMSA	Dimercaptosuccinic acid
E. coli	*Escherichia coli*
ED	Emergency department
EAU	The European Association of Urology
ECIRS	Endoscopic combined intrarenal surgery
FANS-UAS	Flexible and navigable suction ureteral access sheath
GRADE	Grading of Recommendations Assessment, Development, and Evaluation
HR	Hazard ratio
IV	Intravenous
KUB	Kidney, ureter, bladder radiography

MAG-3	Mercaptoacetyltriglycine
MET	Medical expulsive therapy
MD	Mean difference
M-H	Mantel-Haenszel method
Mini-PCNL	Mini-percutaneous nephrolithotomy
MRI	Magnetic resonance imaging
MUSIC	The Michigan Urological Surgery Improvement Collaborative
NCCT	Non-contrast computed tomography
NSAID	Nonsteroidal anti-inflammatory drug
OR	Odds ratio
PCN	Percutaneous nephrostomy
PCNL	Percutaneous nephrolithotomy
PGC	Practice Guidelines Committee
PICO	Patient, Intervention, Comparison, and Outcome
PPV	Positive predictive value
QALY	Quality-Adjusted Life Years
Random	Random effect model
RCS	Retrospective cohort study
RCT	Randomized controlled trial
RI	Resistive index
RIRS	Retrograde intrarenal surgery
ROBINS-I	Risk of Bias in Non-Randomized Studies
RR	Risk ratio
SIRS	Systemic inflammatory response syndrome
spm	Shocks per minute
SQC	Science & Quality Council
SUFU	Society of Urodynamics, Female Pelvic Medicine & Urogenital Reconstruction

SWL	Shockwave lithotripsy
TXA	Tranexamic acid
UAS	Ureteral access sheath
URS	Ureteroscopy
US	Ultrasound
UTI	Urinary tract infection
WMD	Weighted mean difference

APPENDIX 1. META-ANALYSIS MEDICAL EXPULSIVE THERAPY VERSUS STANDARD OF CARE

Summary

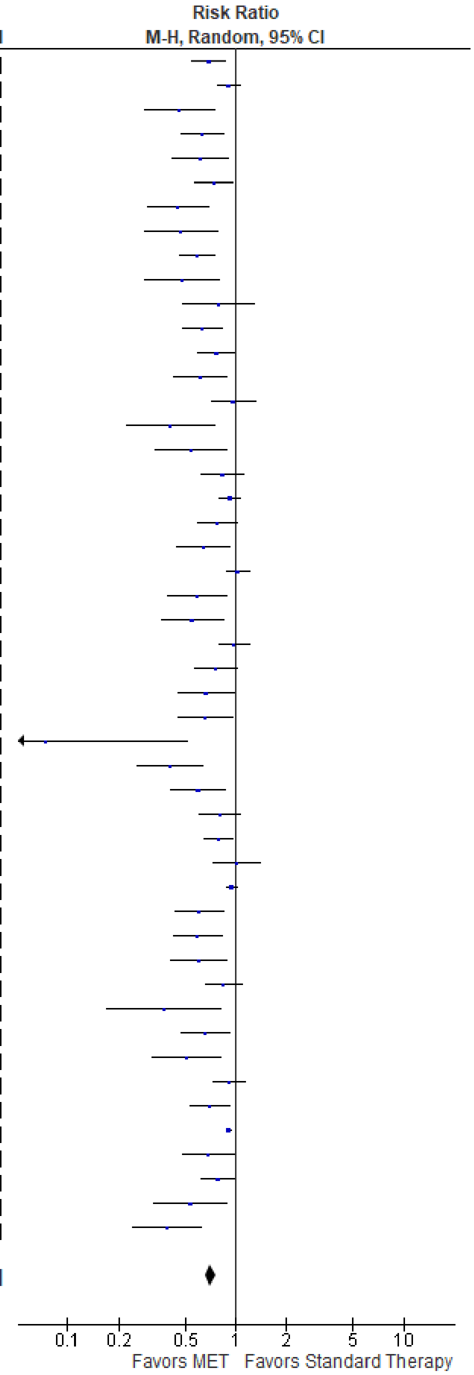
Outcome or Subgroup	**Number of Studies**	**Number of Patients**	**Method**	**Risk Ratio (RR; 95%CI) or Mean Difference (MD; 95%CI)***
Stone Clearance (≤10mm stones)				
Distal ureteral stones	49	8,529	RR (M-H, Random [random effect model])	**0.71; 0.66-0.76**
Mid ureteral stones	4	193	RR (M-H, Random)	0.88; 0.50-1.55
Proximal ureteral stones	6	628	RR (M-H, Random)	0.84; 0.62-1.13
Rate of Surgical Intervention	16	2,844	RR (M-H, Random)	**0.70; 0.51-0.95**
Pain Episodes	16	1,539	Mean Difference [MD] (IV, Random)	**-0.60; -0.82 to -0.37**
Distal ureteral stones	15	1431	MD (IV, Random)	**-0.59; -0.82 to -0.37**
Proximal ureteral stones	1	108	MD (IV, Random)	-0.80; -2.31 to 0.71
Pain Medication Dose				
Distal ureteral stones	17	4,757	MD (IV, Random)	**-72.75; -107.87 to -37.63**
Rate of ED Visits	10	1,172	RR (M-H, Random)	**0.50; 0.33-0.75**
Distal ureteral stones	9	1,080	RR (M-H, Random)	**0.43; 0.25-0.74**
Proximal ureteral stones	1	92	RR (M-H, Random)	0.64; 0.39-1.06

*Bold text defines significant difference between groups for RR or MD at p<0.05

Appendix 1a. Stone Clearance for Medical Expulsive Therapy Versus Standard of Care in Distal Stones ≤10mm

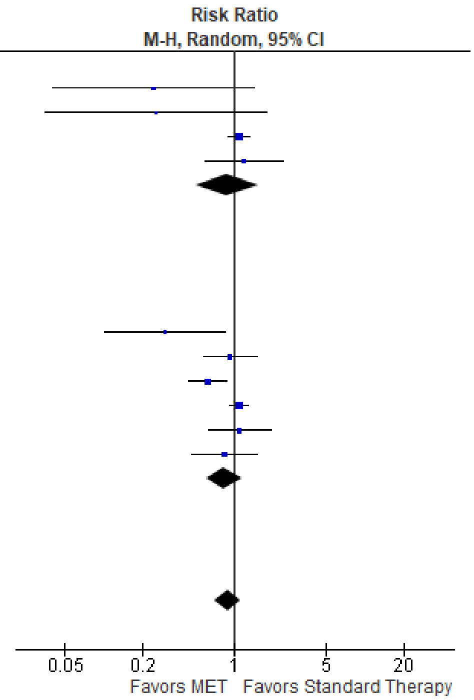
	Standard Therapy		MET			Risk Ratio
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% CI
Abdel-Meguid 2010	42	75	61	75	2.6%	0.69 [0.55, 0.86]
Afridi 2024	48	60	53	60	3.1%	0.91 [0.77, 1.06]
Agrawal 2009	12	34	52	68	1.4%	0.46 [0.29, 0.74]
Ahmad 2015	26	48	42	49	2.3%	0.63 [0.48, 0.84]
Ahmed 2010	14	28	48	59	1.7%	0.61 [0.42, 0.91]
Al-Ansari 2010	28	46	41	50	2.4%	0.74 [0.57, 0.97]
Albert 2016	15	40	66	80	1.6%	0.45 [0.30, 0.69]
Aldemir 2011	11	29	25	31	1.3%	0.47 [0.29, 0.77]
Autorino 2005	27	46	45	45	2.6%	0.59 [0.46, 0.75]
Bajwa 2013	11	30	23	30	1.3%	0.48 [0.29, 0.80]
Bashir 2023	15	35	19	35	1.3%	0.79 [0.48, 1.29]
Bayraktar 2017	33	64	49	60	2.4%	0.63 [0.48, 0.82]
Cervenàkov 2002	32	52	41	51	2.5%	0.77 [0.59, 0.99]
Cha 2012	16	34	82	107	1.8%	0.61 [0.42, 0.89]
Doluoglu 2015	18	23	17	21	2.2%	0.97 [0.72, 1.30]
Erkan 2011	9	34	24	37	1.0%	0.41 [0.22, 0.75]
Erturhan 2007	12	30	22	30	1.3%	0.55 [0.33, 0.89]
Falahatkar 2021	25	44	60	88	2.2%	0.83 [0.62, 1.12]
Furyk 2016	127	195	140	198	3.2%	0.92 [0.80, 1.06]
Griwan 2010	21	30	27	30	2.4%	0.78 [0.60, 1.01]
Han 2006	17	32	29	35	1.9%	0.64 [0.45, 0.92]
Hermanns 2009	40	45	39	45	3.1%	1.03 [0.88, 1.20]
Ibrahim 2013	12	23	46	52	1.7%	0.59 [0.39, 0.88]
Islam 2012	13	28	27	32	1.6%	0.55 [0.36, 0.84]
Itoh 2011	36	46	36	45	2.8%	0.98 [0.79, 1.21]
Itoh 2013	31	56	40	55	2.3%	0.76 [0.57, 1.01]
Kim 2007	12	20	19	21	1.8%	0.66 [0.45, 0.97]
Liatsikos 2007	16	31	33	42	1.8%	0.66 [0.45, 0.96]
Lojanapiwat 2008	1	25	27	50	0.1%	0.07 [0.01, 0.51]
Maitra 2012	15	50	37	50	1.5%	0.41 [0.26, 0.64]
Mshemish 2012	16	34	52	66	1.8%	0.60 [0.41, 0.87]
Mukhtarov 2007	18	25	24	27	2.3%	0.81 [0.61, 1.07]
Nuraj 2017	37	52	47	52	2.9%	0.79 [0.65, 0.96]
Ochoa-Gómez 2011	23	33	22	32	2.1%	1.01 [0.73, 1.40]
Pickard 2015	202	246	430	496	3.5%	0.95 [0.89, 1.01]
Porpiglia 2009	22	45	37	46	2.0%	0.61 [0.44, 0.85]
Rahim 2012	22	45	37	45	2.0%	0.59 [0.43, 0.83]
Samir 2023	22	60	36	59	1.7%	0.60 [0.41, 0.89]
Sayed 2008	22	30	26	30	2.5%	0.85 [0.65, 1.09]
Sen 2017	5	19	33	47	0.7%	0.37 [0.17, 0.81]
Sur 2015	27	59	36	52	2.0%	0.66 [0.47, 0.92]
Taghavi 2005	11	24	18	20	1.4%	0.51 [0.32, 0.81]
Vincendeau 2010	43	61	47	61	2.7%	0.91 [0.74, 1.13]
Wang 2016	33	61	48	62	2.4%	0.70 [0.53, 0.91]
Ye 2018	1300	1654	1419	1642	3.6%	0.91 [0.88, 0.94]
Yilmaz 2005	15	28	67	86	1.9%	0.69 [0.48, 0.99]
Yuksel 2015	25	35	32	35	2.6%	0.78 [0.62, 0.99]
Zehri 2010	12	32	23	33	1.3%	0.54 [0.33, 0.89]
Zhou 2011	13	43	68	88	1.4%	0.39 [0.25, 0.62]
Total (95% CI)		**3919**		**4610**	**100.0%**	**0.71 [0.66, 0.76]**
Total events	2603		3772			

Heterogeneity: $Tau^2 = 0.04$; $Chi^2 = 208.82$, df = 48 (P < 0.00001); $I^2 = 77\%$
Test for overall effect: Z = 9.70 (P < 0.00001)



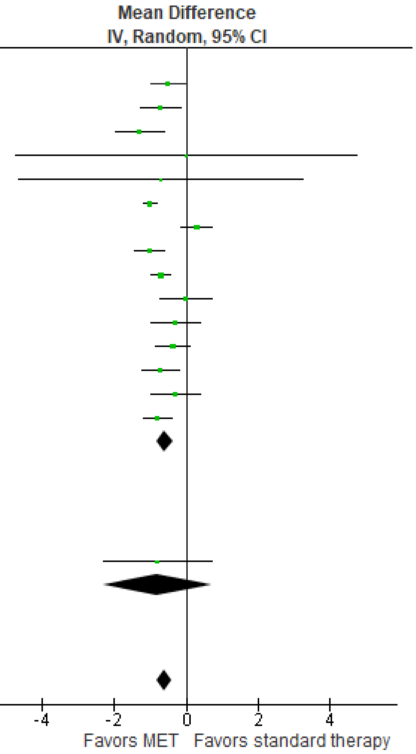
Appendix 1b. Stone Clearance for Medical Expulsive Therapy versus Standard of Care in Mid and Proximal Ureter Stones ≤10mm

	Standard Therapy		MET			Risk Ratio
Study or Subgroup	**Events**	**Total**	**Events**	**Total**	**Weight**	**M-H, Random, 95% CI**
1.10.1 Mid Ureteral Stone						
Ibrahim 2013	1	5	5	6	1.4%	0.24 [0.04, 1.44]
Itoh 2011	1	8	4	8	1.2%	0.25 [0.04, 1.77]
Pickard 2015	36	44	61	81	20.4%	1.09 [0.90, 1.31]
Sur 2015	10	21	8	20	7.0%	1.19 [0.59, 2.40]
Subtotal (95% CI)		**78**		**115**	**30.0%**	**0.88 [0.50, 1.55]**
Total events	48		78			
Heterogeneity: Tau² = 0.14; Chi² = 5.70, df = 3 (P = 0.13); I² = 47%						
Test for overall effect: Z = 0.43 (P = 0.67)						
1.10.2 Proximal Ureteral Stone						
Ibrahim 2013	3	14	8	11	3.6%	0.29 [0.10, 0.86]
Itoh 2011	15	28	15	26	11.2%	0.93 [0.58, 1.50]
Lee 2014	25	54	40	54	15.6%	0.63 [0.45, 0.87]
Pickard 2015	65	89	120	180	21.2%	1.10 [0.93, 1.29]
Sur 2015	15	37	16	43	9.5%	1.09 [0.63, 1.89]
Yencilek 2010	15	50	15	42	8.8%	0.84 [0.47, 1.51]
Subtotal (95% CI)		**272**		**356**	**70.0%**	**0.84 [0.62, 1.13]**
Total events	138		214			
Heterogeneity: Tau² = 0.08; Chi² = 14.86, df = 5 (P = 0.01); I² = 66%						
Test for overall effect: Z = 1.16 (P = 0.25)						
Total (95% CI)		**350**		**471**	**100.0%**	**0.89 [0.71, 1.10]**
Total events	186		292			
Heterogeneity: Tau² = 0.05; Chi² = 21.67, df = 9 (P = 0.010); I² = 58%						
Test for overall effect: Z = 1.08 (P = 0.28)						
Test for subgroup differences: Chi² = 0.03, df = 1 (P = 0.87), I² = 0%						



Appendix 1c. Pain Episodes for Medical Expulsive Therapy Versus Standard of Care by Stone Location*

	MET			Standard Therapy				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
1.2.1 Distal Ureteral Stone								
Ahmed 2010	1.3	0.6	59	1.8	1.2	28	7.7%	-0.50 [-0.97, -0.03]
Al-Ansari 2010	1.6	1.3	50	2.3	1.4	46	6.9%	-0.70 [-1.24, -0.16]
Albert 2016	3	1.8	80	4.3	1.8	40	5.6%	-1.30 [-1.98, -0.62]
Ferre 2009	7.9	10.1	35	7.9	10	34	0.2%	0.00 [-4.74, 4.74]
Griwan 2010	0.6	0.7	30	1.3	11	30	0.3%	-0.70 [-4.64, 3.24]
Mshemish 2012	1.2	0.4	66	2.2	0.5	34	10.9%	-1.00 [-1.19, -0.81]
Porpiglia 2009	1.4	1.1	46	1.1	1	45	8.2%	0.30 [-0.13, 0.73]
Sayed 2008	1.5	0.3	45	2.5	1.4	45	8.3%	-1.00 [-1.42, -0.58]
Sen 2017	0.6	0.4	47	1.3	0.5	19	10.3%	-0.70 [-0.95, -0.45]
Vincendeau 2010	2.6	2.1	60	2.6	1.9	59	5.2%	0.00 [-0.72, 0.72]
Wang 2008	1.9	1.5	64	2.2	1.6	31	5.6%	-0.30 [-0.97, 0.37]
Wang 2016	2.39	1.3	61	2.75	1.38	62	7.7%	-0.36 [-0.83, 0.11]
Yilmaz 2005	1.7	0.5	86	2.4	1.4	28	7.1%	-0.70 [-1.23, -0.17]
Yuksel 2015	1.2	1.4	35	1.5	1.5	35	5.6%	-0.30 [-0.98, 0.38]
Zhou 2011	1.3	1.4	88	2.1	0.9	43	8.6%	-0.80 [-1.20, -0.40]
Subtotal (95% CI)			**852**			**579**	**98.2%**	**-0.59 [-0.82, -0.37]**
Heterogeneity: Tau² = 0.11; Chi² = 44.06, df = 14 (P < 0.0001); I² = 68%								
Test for overall effect: Z = 5.13 (P < 0.00001)								
1.2.2 Proximal Ureteral Stone								
Lee 2014	3.5	3.8	54	4.3	4.2	54	1.8%	-0.80 [-2.31, 0.71]
Subtotal (95% CI)			**54**			**54**	**1.8%**	**-0.80 [-2.31, 0.71]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 1.04 (P = 0.30)								
Total (95% CI)			**906**			**633**	**100.0%**	**-0.60 [-0.82, -0.37]**
Heterogeneity: Tau² = 0.11; Chi² = 44.07, df = 15 (P = 0.0001); I² = 66%								
Test for overall effect: Z = 5.29 (P < 0.00001)								
Test for subgroup differences: Chi² = 0.07, df = 1 (P = 0.79), I² = 0%								



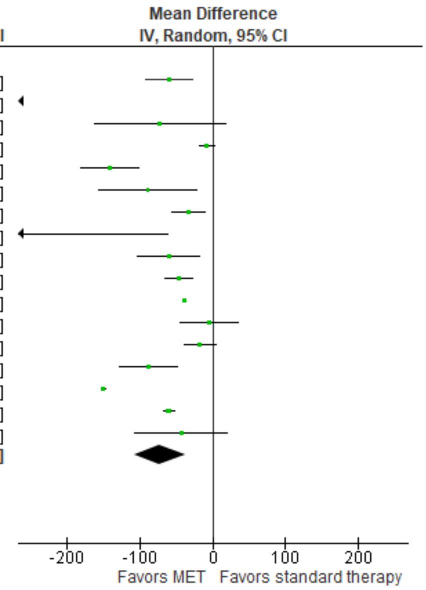
* No studies of solely mid-ureteral stones reported on pain episodes; no studies of multiple stone locations reported on pain episodes in a mid-ureter subgroup

Appendix 1d. Pain Medication Dosage for Medical Expulsive Therapy Versus Standard of Care in Distal Ureteral Stones*

Study or Subgroup	MET Mean	MET SD	MET Total	Standard Therapy Mean	Standard Therapy SD	Standard Therapy Total	Weight	Mean Difference IV, Random, 95% CI
1.3.1 Distal Ureteral Stone								
Al-Ansari 2010	67.5	69.8	50	127.2	89.3	46	6.6%	-59.70 [-91.95, -27.45]
Balci 2014	544	493	25	1,408	622	25	1.1%	-864.00 [-1175.12, -552.88]
Bashir 2023	565.3	213	35	637.5	166	35	4.8%	-72.20 [-161.66, 17.26]
Bayraktar 2017	97.5	30	60	105	30	64	7.0%	-7.50 [-18.07, 3.07]
El-Gamal 2012	43.5	65.3	48	184.5	120	46	6.5%	-141.00 [-180.29, -101.71]
Falahatkar 2021	165.9	219.6	44	254.54	54	44	5.6%	-88.64 [-155.46, -21.82]
Griwan 2010	30	33.7	30	63.3	55.6	30	6.8%	-33.30 [-56.57, -10.03]
Hermanns 2009	335	440	45	630	670	45	1.7%	-295.00 [-529.20, -60.80]
Itoh 2013	15	45	55	75	155	56	6.4%	-60.00 [-102.30, -17.70]
Nuraj 2017	63.7	45.2	52	109.2	53	52	6.9%	-45.50 [-64.43, -26.57]
Porpiglia 2006	42.5	0.4	33	81	0.3	24	7.0%	-38.50 [-38.68, -38.32]
Porpiglia 2009	122.7	101	46	127.4	95	45	6.4%	-4.70 [-44.98, 35.58]
Samir 2023	126.6	44.2	59	143.8	75.9	60	6.8%	-17.20 [-39.47, 5.07]
Wang 2016	255.97	112.48	62	343.77	109.9	61	6.5%	-87.80 [-127.10, -48.50]
Ye 2018	86	32	1642	236	62	1654	7.0%	-150.00 [-153.37, -146.63]
Yilmaz 2005	122	14.5	86	182.1	19.8	28	7.0%	-60.10 [-68.05, -52.15]
Yuksel 2015	113.6	130.4	35	156.4	140.2	35	5.7%	-42.80 [-106.23, 20.63]
Subtotal (95% CI)			**2407**			**2350**	**100.0%**	**-72.75 [-107.87, -37.63]**

Heterogeneity: Tau² = 4562.65; Chi² = 4342.53, df = 16 (P < 0.00001); I² = 100%
Test for overall effect: Z = 4.06 (P < 0.0001)

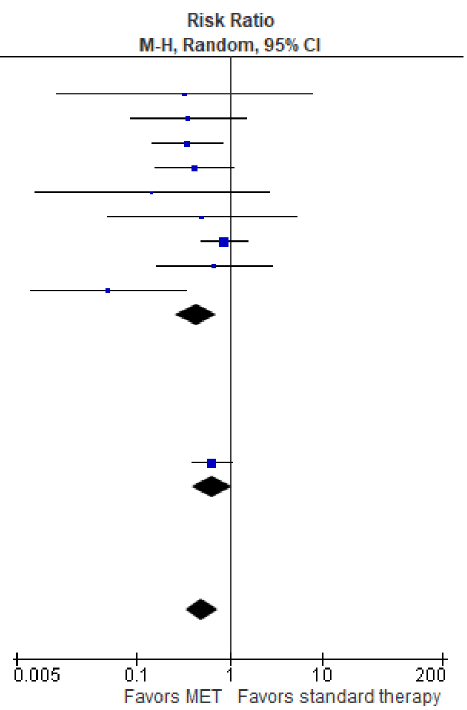
Test for subgroup differences: Not applicable



* No identified study reported on pain medication dose in a mid or proximal stone location.

Appendix 1e. Rate of Emergency Department Visits for Medical Expulsive Therapy Versus Standard of Care by Stone Location *

Study or Subgroup	MET Events	MET Total	Standard Therapy Events	Standard Therapy Total	Weight	Risk Ratio M-H, Random, 95% CI
1.4.1 Distal Ureteral Stone						
Ahmad 2015	0	49	1	48	1.6%	0.33 [0.01, 7.83]
Ahmed 2010	3	59	4	28	6.9%	0.36 [0.09, 1.48]
Albert 2016	7	80	10	40	14.2%	0.35 [0.14, 0.85]
Autorino 2005	5	50	11	46	12.4%	0.42 [0.16, 1.11]
El Said 2015	0	26	3	26	1.9%	0.14 [0.01, 2.63]
Erturhan 2007	1	30	2	30	2.9%	0.50 [0.05, 5.22]
Furyk 2016	20	202	23	201	23.4%	0.87 [0.49, 1.52]
Mshemish 2012	4	66	3	34	6.8%	0.69 [0.16, 2.90]
Zehri 2010	1	33	20	32	4.0%	0.05 [0.01, 0.34]
Subtotal (95% CI)		**595**		**485**	**74.2%**	**0.43 [0.25, 0.74]**
Total events	41		77			
Heterogeneity: Tau² = 0.19; Chi² = 11.77, df = 8 (P = 0.16); I² = 32%						
Test for overall effect: Z = 3.09 (P = 0.002)						
1.4.2 Proximal Ureteral Stone						
Yencilek 2010	14	42	26	50	25.8%	0.64 [0.39, 1.06]
Subtotal (95% CI)		**42**		**50**	**25.8%**	**0.64 [0.39, 1.06]**
Total events	14		26			
Heterogeneity: Not applicable						
Test for overall effect: Z = 1.73 (P = 0.08)						
Total (95% CI)		**637**		**535**	**100.0%**	**0.50 [0.33, 0.75]**
Total events	55		103			
Heterogeneity: Tau² = 0.10; Chi² = 12.36, df = 9 (P = 0.19); I² = 27%						
Test for overall effect: Z = 3.34 (P = 0.0008)						
Test for subgroup differences: Chi² = 1.12, df = 1 (P = 0.29), I² = 10.5%						

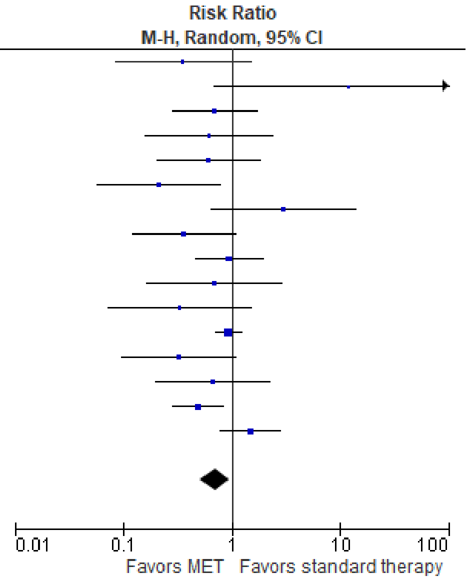


*No identified study reports on rate of ED visits in mid ureter locations.

Appendix 1f. Rate of Surgical Intervention for Medical Expulsive Therapy Versus Standard of Care*

Study or Subgroup	MET Events	MET Total	Standard Therapy Events	Standard Therapy Total	Weight	Risk Ratio M-H, Random, 95% CI
Ahmed 2010	3	59	4	28	3.8%	0.36 [0.09, 1.48]
Autorino 2005	6	50	0	46	1.1%	11.98 [0.69, 206.91]
Eryildirim 2015	7	60	10	60	7.3%	0.70 [0.29, 1.72]
Ferre 2009	3	38	5	39	4.1%	0.62 [0.16, 2.40]
Furyk 2016	5	198	8	195	5.6%	0.62 [0.20, 1.85]
Georgescu 2015	3	100	7	50	4.3%	0.21 [0.06, 0.79]
Hermanns 2009	6	45	2	45	3.3%	3.00 [0.64, 14.08]
Lee 2014	4	54	11	54	5.7%	0.36 [0.12, 1.07]
Meltzer 2018	14	214	13	189	9.2%	0.95 [0.46, 1.97]
Mshemish 2012	4	66	3	34	3.7%	0.69 [0.16, 2.90]
Park 2012	2	30	6	30	3.4%	0.33 [0.07, 1.52]
Pickard 2015	71	378	76	379	16.2%	0.94 [0.70, 1.25]
Sen 2017	4	47	5	19	4.9%	0.32 [0.10, 1.08]
Vincendeau 2010	4	61	6	61	4.8%	0.67 [0.20, 2.25]
Wang 2016	14	62	28	61	12.1%	0.49 [0.29, 0.84]
Yencilek 2010	15	42	12	50	10.5%	1.49 [0.79, 2.82]
Total (95% CI)		**1504**		**1340**	**100.0%**	**0.70 [0.51, 0.95]**
Total events	165		196			

Heterogeneity: Tau² = 0.13; Chi² = 25.58, df = 15 (P = 0.04); I² = 41%
Test for overall effect: Z = 2.27 (P = 0.02)



*≤5 mm Stones versus 6-10 mm Stones-no studies reported on rate of surgical intervention by stone size.

Appendix 1 References

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Stone Clearance for Medical Expulsive Therapy versus Standard of Care by Stone Location
Distal
Abdel-Meguid et al. 2010[351]
Afridi et al. 2024[352]
Agrawal et al. 2009[353]
Ahmad et al. 2015[354]
Ahmed and Al-Sayed 2010[355]
Al-Ansari et al. 2010[356]
Albert et al. 2016[357]
Aldemir et al. 2011[358]
Autorino et al. 2005[359]
Bajwa et al. 2013[360]
Bashir et al. 2023[361]
Bayraktar and Albayrak 2017[362]
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Erkan et al. 2011[366]

Erturhan et al. 2007[367]
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Griwan et al. 2010[370]
Han et al. 2006[371]
Hermanns et al. 2009[372]
Ibrahim et al. 2013[373]
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Itoh et al. 2011[375]
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Nuraj and Hyseni 2017[383]
Ochoa-Gómez et al. 2011[384]
Pickard et al. 2015[385]
Porpiglia et al. 2009[386]
Rahim et al. 2012[387]
Samir et al. 2023[388]
Sayed et al. 2008[389]
Sen et al. 2017[390]
Sur et al. 2015[391]
Taghavi et al. 2005[392]
Vincendeau et al. 2010[393]
Wang et al. 2016[394]
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Yilmaz et al. 2005[396]
Yuksel et al. 2015[397]
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Stone Clearance for Medical Expulsive Therapy versus Standard of Care in Mid and Proximal Ureter Stones ≤10mm
Mid Ureteral Stone
Ibrahim et al. 2013[373]
Itoh et al. 2011[375]
Pickard et al. 2015[385]
Sur et al. 2015[391]
Proximal Ureteral Stone
Ibrahim et al. 2013[373]
Itoh et al. 2011[375]
Lee et al. 2014[400]
Pickard et al. 2015[385]
Sur et al. 2015[391]
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Pain Episodes for Medical Expulsive Therapy versus Standard of Care by Stone Location
Distal Ureteral Stone
Ahmed and Al-Sayed 2010[355]
Al-Ansari et al. 2010[356]
Albert et al. 2016[357]
Ferre et al. 2009[402]
Griwan et al. 2010[370]
Mshemish 2012[381]
Porpiglia et al. 2009[386]
Sayed et al. 2008[389]
Sen et al. 2017[390]
Vincendeau et al. 2010[393]
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Wang et al. 2016[394]
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Yuksel et al. 2015[397]
Zhou et al. 2011[399]
Proximal Ureteral Stone
Lee et al. 2014[400]

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Ahmad et al. 2015[354]
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Mshemish 2012[381]
Zehri et al. 2010[398]
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Yencilek et al. 2010[401]

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Autorino et al. 2005[359]
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Hermanns et al. 2009[372]
Lee et al. 2014[400]
Meltzer 2018[410]
Mshemish 2012[381]
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Sen et al. 2017[390]
Vincendeau et al. 2010[393]
Wang et al. 2016[394]
Yencilek et al. 2010[401]

APPENDIX 2. META-ANALYSIS OF STONE-FREE RATE FOR SWL VERSUS URS, SWL VERSUS PCNL, AND URS VERSUS MINI-PCNL

Summary

Subgroup	Number of Studies	Number of Patients	Method	Risk Ratio (RR; 95%CI)*
SWL versus URS	24	n=3,934	Risk Ratio [RR] (M-H, Random)	**0.83; 0.77-0.89 (RR<1 favors URS)**
Lower pole stones	10	n=1242	RR (M-H, Random)	**0.86; 0.78-0.95**
Distal ureter stones†	2	n=373	RR (M-H, Random)	0.87; 0.64-1.18
Proximal ureter stones	5	n=992	RR (M-H, Random)	**0.72; 0.60-0.86**
SWL versus PCNL	11	n=1,219	RR (M-H, Random)	**0.64; 0.53-0.76 (RR<1 favors PCNL)**
Lower pole stones‡	7	n=960	RR (M-H, Random)	**0.70; 0.61-0.80**
Non-lower pole stones	4	n=259	RR (M-H, Random)	0.45; 0.14-1.50
Standard PCNL versus URS				
>2cm stones	3	n=224	RR (M-H Random)	**1.61; 1.00-2.57 (RR>1 favors PCNL)**
Mini-PCNL versus URS				
1-2cm stones	10	n=1303	RR (M-H, Random)	**1.11; 1.03-1.20 (RR>1 favors mini-PCNL)**

*Bold text defines significant difference in stone-free rates between groups at $p<0.05$

†Based on identification of only two studies, this summary of effect estimate was interpreted with caution as the reliability and generalizability of the findings is reduced

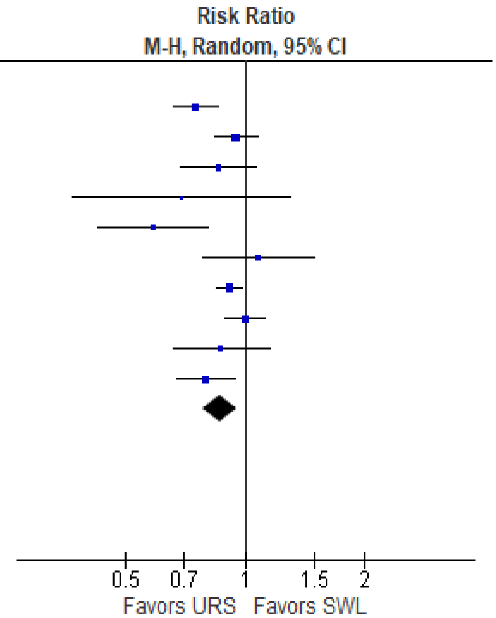
‡Identified studies included patients with stones >1 cm in size

Appendix 2a. Stone-free rate for URS versus SWL in Lower Pole Kidney Stone Location

Study or Subgroup	SWL Events	SWL Total	URS Events	URS Total	Weight	Risk Ratio M-H, Random, 95% CI
2.2.2 Lower Pole Stones						
Bozzini 2017	120	194	170	207	13.6%	0.75 [0.66, 0.86]
Kumar 2015a	74	90	78	90	13.7%	0.95 [0.84, 1.08]
Kumar 2015b	31	42	37	43	9.4%	0.86 [0.69, 1.07]
Pearle 2008	9	26	16	32	2.1%	0.69 [0.37, 1.30]
Salem 2013	17	30	29	30	6.1%	0.59 [0.43, 0.81]
Schoenthaler 2022	13	15	12	15	6.0%	1.08 [0.79, 1.49]
Sener 2014	64	70	70	70	16.1%	0.91 [0.85, 0.99]
Sener 2015	46	50	46	50	14.2%	1.00 [0.89, 1.12]
Terribile 2019	23	33	28	35	7.2%	0.87 [0.66, 1.15]
Zhang 2019	44	60	55	60	11.5%	0.80 [0.67, 0.95]
Subtotal (95% CI)		**610**		**632**	**100.0%**	**0.86 [0.78, 0.95]**
Total events	441		541			

Heterogeneity: Tau² = 0.01; Chi² = 28.19, df = 9 (P = 0.0009); I² = 68%
Test for overall effect: Z = 2.94 (P = 0.003)

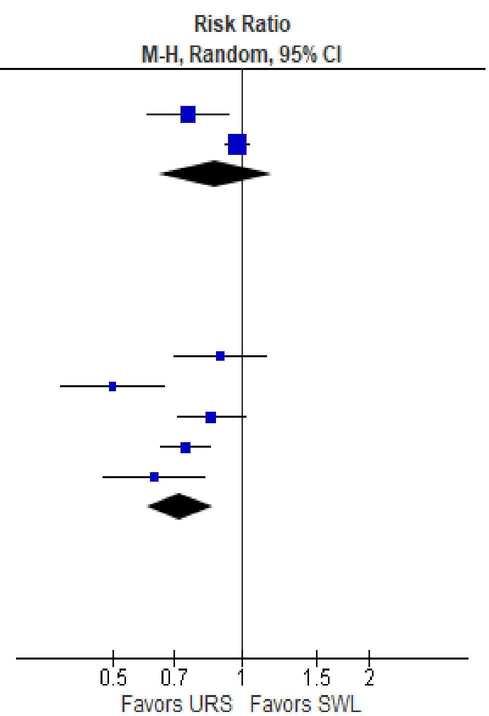
Test for subgroup differences: Not applicable



Appendix 2b. Stone-free rate for URS versus SWL by Ureteral Stone Location

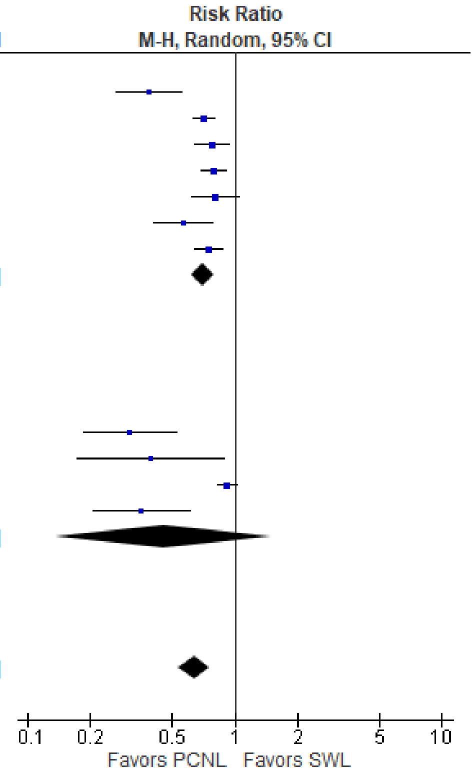
Study or Subgroup	SWL Events	SWL Total	URS Events	URS Total	Weight	Risk Ratio M-H, Random, 95% CI
2.3.1 Distal Ureter Stones						
Adnan 2021	33	50	44	50	43.8%	0.75 [0.60, 0.94]
Verze 2010	127	137	129	136	56.2%	0.98 [0.92, 1.04]
Subtotal (95% CI)		**187**		**186**	**100.0%**	**0.87 [0.64, 1.18]**
Total events	160		173			
Heterogeneity: Tau² = 0.04; Chi² = 6.99, df = 1 (P = 0.008); I² = 86%						
Test for overall effect: Z = 0.90 (P = 0.37)						
2.3.3 Proximal Ureter Stones						
Bangash 2020	34	50	38	50	18.6%	0.89 [0.70, 1.14]
El-Abd 2022	35	90	70	90	16.7%	0.50 [0.38, 0.66]
Manzoor 2013	98	199	115	199	22.2%	0.85 [0.71, 1.02]
Salem 2009	71	100	96	100	25.3%	0.74 [0.65, 0.84]
Ur Rehman 2020	30	57	48	57	17.2%	0.63 [0.48, 0.82]
Subtotal (95% CI)		**496**		**496**	**100.0%**	**0.72 [0.60, 0.86]**
Total events	268		367			
Heterogeneity: Tau² = 0.03; Chi² = 13.58, df = 4 (P = 0.009); I² = 71%						
Test for overall effect: Z = 3.70 (P = 0.0002)						

Test for subgroup differences: Chi² = 1.13, df = 1 (P = 0.29), I² = 11.4%



Appendix 2c. Stone-free rate for PCNL versus SWL by Stone Location

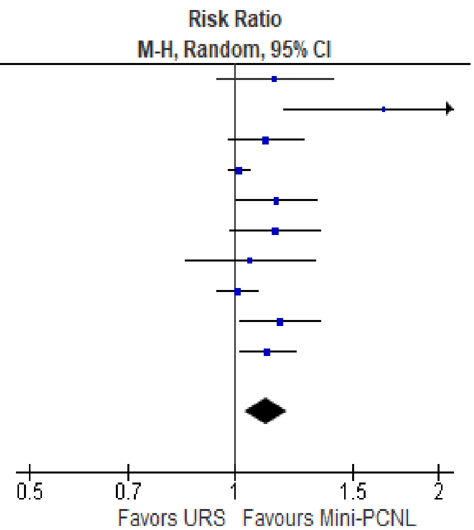
Study or Subgroup	SWL Events	SWL Total	PCNL Events	PCNL Total	Weight	Risk Ratio M-H, Random, 95% CI
3.1.1 Lower Pole Stones						
Albala 2001	19	52	52	55	8.2%	0.39 [0.27, 0.56]
Bozzini 2017	120	194	158	181	11.9%	0.71 [0.63, 0.80]
Kumar 2015a	31	42	39	41	10.9%	0.78 [0.64, 0.94]
Soliman 2021	57	75	72	75	11.7%	0.79 [0.69, 0.91]
Terribile 2019	23	33	26	30	9.8%	0.80 [0.62, 1.05]
Yuruk 2010	17	31	30	31	8.8%	0.57 [0.41, 0.78]
Zhang 2019	44	60	59	60	11.5%	0.75 [0.64, 0.87]
Subtotal (95% CI)		**487**		**473**	**72.8%**	**0.70 [0.61, 0.80]**
Total events	311		436			
Heterogeneity: Tau² = 0.02; Chi² = 18.64, df = 6 (P = 0.005); I² = 68%						
Test for overall effect: Z = 5.38 (P < 0.00001)						
3.1.2 Non-Lower Pole Stones						
Ahmed 2021	10	33	33	34	6.0%	0.31 [0.19, 0.53]
Deem 2011	4	12	17	20	3.4%	0.39 [0.17, 0.89]
Gadelkareem 2020	36	40	39	40	12.0%	0.92 [0.82, 1.04]
Gadelmoula 2019	11	40	31	40	5.9%	0.35 [0.21, 0.60]
Subtotal (95% CI)		**125**		**134**	**27.2%**	**0.45 [0.14, 1.50]**
Total events	61		120			
Heterogeneity: Tau² = 1.42; Chi² = 91.73, df = 3 (P < 0.00001); I² = 97%						
Test for overall effect: Z = 1.29 (P = 0.20)						
Total (95% CI)		**612**		**607**	**100.0%**	**0.64 [0.53, 0.76]**
Total events	372		556			
Heterogeneity: Tau² = 0.06; Chi² = 71.84, df = 10 (P < 0.00001); I² = 86%						
Test for overall effect: Z = 5.02 (P < 0.00001)						
Test for subgroup differences: Chi² = 0.50, df = 1 (P = 0.48), I² = 0%						



Appendix 2d. Stone-free rate for URS versus mini-PCNL for 1-2 cm Stones

	Mini-PCNL		URS			Risk Ratio
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% CI
Agrawal 2016	23	24	20	24	7.4%	1.15 [0.94, 1.40]
Dutta 2023	39	51	23	50	3.6%	1.66 [1.19, 2.33]
Jain 2021	39	40	35	40	10.7%	1.11 [0.98, 1.27]
Jin 2019	105	106	107	110	15.3%	1.02 [0.98, 1.06]
Kumar 2023	45	47	44	53	10.3%	1.15 [1.01, 1.32]
Perri 2022	81	96	66	90	9.5%	1.15 [0.99, 1.34]
Sajjad 2023	38	48	36	48	6.6%	1.06 [0.85, 1.31]
Tang 2023	83	87	81	86	13.9%	1.01 [0.94, 1.09]
Ur Rehman 2023	69	75	59	75	10.3%	1.17 [1.02, 1.34]
Zeng 2018	75	77	66	76	12.5%	1.12 [1.02, 1.23]
Total (95% CI)		**651**		**652**	**100.0%**	**1.11 [1.03, 1.20]**
Total events	597		537			

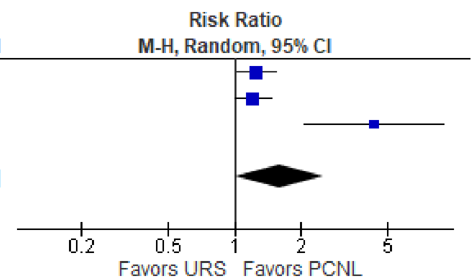
Heterogeneity: Tau² = 0.01; Chi² = 38.19, df = 9 (P < 0.0001); I² = 76%
Test for overall effect: Z = 2.86 (P = 0.004)



Appendix 2e. Stone-free rate for URS versus Standard PCNL for >2 cm Stones

	PCNL		URS			Risk Ratio
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% CI
Bryniarski 2012	30	32	24	32	39.0%	1.25 [1.00, 1.56]
Çakıcı 2020	45	50	37	50	39.9%	1.22 [1.01, 1.47]
Karakoyunlu 2015	26	30	6	30	21.1%	4.33 [2.09, 8.99]
Total (95% CI)		**112**		**112**	**100.0%**	**1.61 [1.00, 2.57]**
Total events	101		67			

Heterogeneity: Tau² = 0.14; Chi² = 15.84, df = 2 (P = 0.0004); I² = 87%
Test for overall effect: Z = 1.97 (P = 0.05)

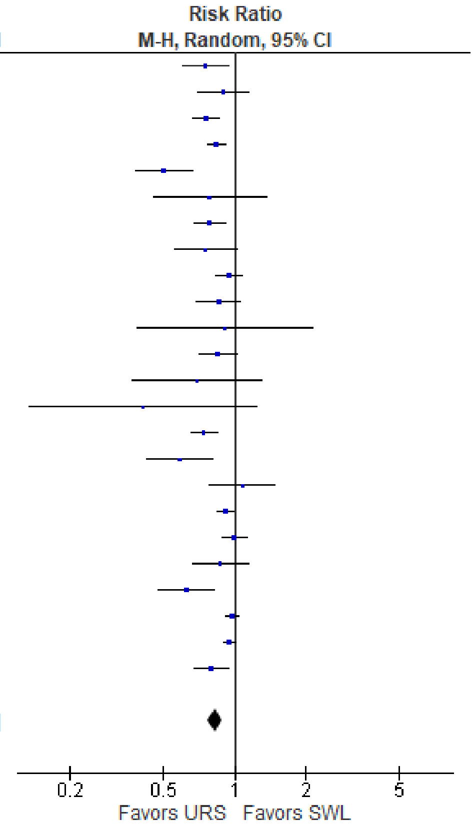


Appendix 2f. Stone-free rate for SWL versus URS

Study or Subgroup	SWL Events	SWL Total	URS Events	URS Total	Weight	Risk Ratio M-H, Random, 95% CI
Adnan 2021	33	50	44	50	4.1%	0.75 [0.60, 0.94]
Bangash 2020	34	50	38	50	3.8%	0.89 [0.70, 1.14]
Bozzini 2017	120	194	170	207	5.9%	0.75 [0.66, 0.86]
Dasgupta 2022	185	250	235	266	6.6%	0.84 [0.77, 0.91]
El-Abd 2022	35	90	70	90	3.3%	0.50 [0.38, 0.66]
Fankhauser 2021	10	21	14	23	1.3%	0.78 [0.45, 1.36]
Islam 2012	50	68	64	68	5.3%	0.78 [0.67, 0.91]
Javanmard 2015	17	25	19	21	3.0%	0.75 [0.56, 1.02]
Kumar 2015a	74	90	78	90	5.9%	0.95 [0.84, 1.08]
Kumar 2015b	31	42	37	43	4.2%	0.86 [0.69, 1.07]
Lee 2006	7	22	7	20	0.6%	0.91 [0.39, 2.14]
Manzoor 2013	98	199	115	199	4.8%	0.85 [0.71, 1.02]
Pearle 2008	9	26	16	32	1.0%	0.69 [0.37, 1.30]
Ravier 2015	3	11	4	6	0.4%	0.41 [0.13, 1.25]
Salem 2009	71	100	96	100	5.8%	0.74 [0.65, 0.84]
Salem 2013	17	30	29	30	2.8%	0.59 [0.43, 0.81]
Schoenthaler 2022	13	15	12	15	2.8%	1.08 [0.79, 1.49]
Sener 2014	64	70	70	70	6.7%	0.91 [0.85, 0.99]
Sener 2015	46	50	46	50	6.1%	1.00 [0.89, 1.12]
Terribile 2019	23	33	28	35	3.3%	0.87 [0.66, 1.15]
Ur Rehman 2020	30	57	48	57	3.4%	0.63 [0.48, 0.82]
Verze 2010	127	137	129	136	7.0%	0.98 [0.92, 1.04]
Zhang 2011	227	257	250	269	7.0%	0.95 [0.90, 1.00]
Zhang 2019	44	60	55	60	5.0%	0.80 [0.67, 0.95]
Total (95% CI)		**1947**		**1987**	**100.0%**	**0.83 [0.77, 0.89]**
Total events	1368		1674			

Heterogeneity: Tau² = 0.02; Chi² = 100.35, df = 23 (P < 0.00001); I² = 77%

Test for overall effect: Z = 5.45 (P < 0.00001)



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Terribile et al. 2019[416]
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Verze et al. 2010[194]
Proximal Ureteral Stones
Bangash et al. 2020[196]
El-Abd et al. 2022[83]
Manzoor et al. 2013[193]
Salem 2009[76]
Ur Rehman et al. 2020[417]

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Bozzini et al. 2017[197]
Kumar Kumar et al. 2015a[412]
Soliman et al. 2021[418]
Terribile et al. 2019[416]
Yuruk et al. 2010[419]
Zhang et al. 2019[122]
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Deem et al. 2011[421]
Gadelkareem et al. 2020[422]
Gadelmoula et al. 2019[137]

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Agrawal et al. 2016[423]
Dutta et al. 2023[141]
Jain et al. 2021[146]
Jin et al. 2019[148]
Kumar et al. 2023[145]
Perri et al. 2022[147]
Sajjad et al. 2023[424]
Tang et al. 2023[144]
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Zeng 2018[425]

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Bozzini et al. 2017[197]
Dasgupta et al. 2022[75]
El-Abd et al. 2022[83]
Fankhauser et al. 2021[428]
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Appendix 3. META-ANALYSIS FOR STONE CLEARANCE USING SWL

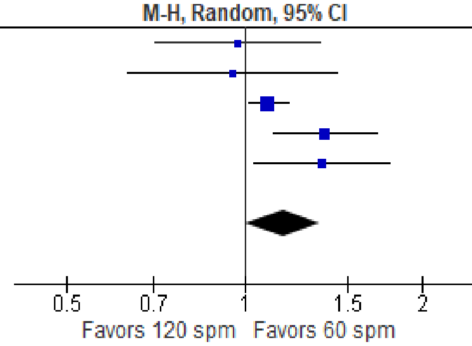
Appendix 3a. Stone Clearance using SWL with Shock Rate of 60 per Minute Versus 120 Shocks per Minute

	60 spm		120 spm			Risk Ratio
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% CI
Ali 2021	37	75	38	75	13.5%	0.97 [0.71, 1.34]
Davenport 2006	23	50	26	54	9.4%	0.96 [0.64, 1.44]
Madbouly 2005	75	76	72	80	37.2%	1.10 [1.01, 1.18]
Moon 2012	66	81	50	84	22.5%	1.37 [1.12, 1.68]
Pace 2005	66	111	48	109	17.4%	1.35 [1.04, 1.75]
Total (95% CI)		**393**		**402**	**100.0%**	**1.16 [1.01, 1.34]**
Total events	267		234			

Heterogeneity: $Tau^2 = 0.01$; $Chi^2 = 8.43$, df = 4 (P = 0.08); $I^2 = 53\%$

Test for overall effect: Z = 2.05 (P = 0.04)

Risk Ratio
M-H, Random, 95% CI



Appendix 3 References

References for Appendix 3a.

Stone Clearance using SWL with Shock Rate of 60 per Minute Versus 120 Shocks per Minute
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This document was written by the Surgical Management of Kidney and Ureteral Stones Guideline Panel of the American Urological Association Education and Research, Inc., which was created in 2025. The Practice Guidelines Committee (PGC) of the AUA selected the committee chairs and panel members were selected by the chairs. Membership of the panel included specialists with specific expertise on this disease. The mission of the panel was to develop recommendations that are analysis-based or consensus-based, depending on panel processes and available data, for optimal clinical practices in the surgical management of kidney and ureteral stones.

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Although Guidelines are intended to encourage best practices and potentially encompass available technologies with sufficient data as of close of the literature review, they are necessarily time-limited. Guidelines cannot include evaluation of all data on emerging technologies or management, including those that are FDA-approved, which may immediately come to represent accepted clinical practices.

For this reason, the AUA does not regard technologies or management which are too new to be addressed by this Guideline as necessarily experimental or investigational.

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