The Saudi urological association guidelines on urolithiasis

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Abstract

Aims: The Saudi Urolithiasis Guidelines are a set of recommendations for diagnosing, evaluating, and treating urolithiasis in the Saudi population. These guidelines are based on the latest evidence and expert consensus to improve patient outcomes and optimize care delivery. They cover the various aspects of urolithiasis, including risk factors, diagnosis, medical and surgical treatments, and prevention strategies. By following these guidelines, health-care professionals can improve care quality for individuals with urolithiasis in Saudi Arabia.

Panel: The Saudi Urolithiasis Guidelines Panel consists of urologists specialized in endourology with expertise in urolithiasis and consultation with a guideline methodologist. All panelists involved in this document have submitted statements disclosing any potential conflicts of interest.

Methods: The Saudi Guidelines on Urolithiasis were developed by relying primarily on established international guidelines to adopt or adapt the most appropriate guidance for the Saudi context. When necessary, the panel modified the phrasing of recommendations from different sources to ensure consistency within the document. To address areas less well covered in existing guidelines, the panel conducted a directed literature search for high quality evidence published in English, including meta analyses, randomized controlled trials, and prospective nonrandomized comparative studies. The panel also searched for locally relevant studies containing information unique to the Saudi Arabian population. The recommendations are formulated with a direction and strength of recommendation

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Received: 22.12.2023, **Revised:** 24.12.2023, **Accepted:** 28.12.2023, **Published:** 25.01.2024.

Access this article online	
Quick Response Code:	Website: www.urologyannals.com
	DOI: 10.4103/ua.ua_120_23

How to cite this article: Kamal W, Azhar RA, Hamri SB, Alathal AH, Alamri A, Alzahrani T, *et al*. The Saudi urological association guidelines on urolithiasis. Urol Ann 2024;16:1-27.

based on GRADE terminology and interpretation while relying on existing summaries of evidence from the existing guidelines.

Keywords: Percutaneous nephrolithotomy, Saudi Arabia, shock wave lithotripsy, treatment, ureteroscopy, urinary stones, urolithiasis

INTRODUCTION

Aims

The Saudi Urolithiasis Guidelines panel developed these guidelines as a clinical framework for managing urolithiasis. These guidelines are systematically developed statements per evidence-based practice to provide the necessary information to assist urologists and patients in deciding on renal and ureteric calculi treatment plans. It may be a reference for insurance companies and determine the basics of good clinical practice. Nonetheless, the panel emphasizes that these guidelines are not intended to be a substitute for clinical expertise. The variations among individuals' clinical situations, values, and preferences make applying one rule for all inappropriate in most instances. We encourage clinical care in the context of shared decision-making.

Panel

The Saudi Urolithiasis Guidelines Panel consists of a group of urologists subspecialized in endourology with expertise in urolithiasis and in consultation with a guideline methodologist. All panelists involved in this document have submitted potential conflict of interest statements.

METHODS

In elaborating on the Saudi Guidelines on Urolithiasis, we relied primarily on established international guidelines to adopt or adapt the most appropriate guidance to the Saudi context. Where necessary, we modified the phrasing of recommendations from different sources to provide consistency within our document. Panelists were given source documents and supporting materials to review. We then adopted, adapted, or excluded guideline recommendations through the consensus.

The sources of information included:

- The EAU Guidelines on Urolithiasis 2021, published by the EAU
- Medical Management of Kidney Stones: AUA Guidelines, published by the AUA
- Surgical Management of Stones: AUA/Endourological Society Guidelines
- NICE Guideline – Renal and ureteric stones: Assessment and management, published by the National Institute for Health and Care Excellence
- The Urological Association of Asia clinical guideline for urinary stone disease.

To address some areas less well covered in the existing guidelines, the panel performed a directed literature search for a high-quality evidence published in English, including meta-analysis, randomized controlled trials, and prospective nonrandomized comparative studies when necessary. In addition, we searched for locally relevant studies containing information unique to the Saudi Arabian population. Recommendations are formulated with a direction and strength of recommendation based on the GRADE terminology and interpretation but relying on existing summaries of evidence from the existing guidelines.[1]

Within the GRADE framework, recommendations can be for or against and are either strong or conditional. These represent a spectrum of guidance that depends on the relative trade-off between good and bad outcomes, the quality of the evidence, and additional considerations, including economic factors, patient values, feasibility, and equity in a specific health-care system.

A strong recommendation is one in which it is expected that most well-informed patients in this situation would agree with the recommended course of action. Decisions here depend on informed consent, in which a patient can decline a recommended therapy, usually for a specific reason. Therefore, a lower amount of practice variation is expected when following strong recommendations. A conditional recommendation indicates less certainty regarding the best course of action, and management is more strongly dependent on individual patient values. Preferences and decisions here depend on shared decision-making between patients and urologists.

SECTION 1 - DIAGNOSIS AND EVALUATION OF UROLITHIASIS

This section reviews the diagnosis and evaluation of a typical patient with urolithiasis. We present the radiological and laboratory evaluation for the initial diagnosis at presentation. Further discussion *of metabolic evaluation and secondary prevention or surveillance is found in Section 4.*

Introduction

Saudi Arabia, by area, is the largest country in the Middle East, occupying most of the Arabian Peninsula, with approximately 2,150,000 km^2 (830,000 sq mi). The large area led to geographical diversity, including coastal areas, mountains, and deserts. The Saudi population has a 2.5-fold higher risk of developing urolithiasis, reaching a prevalence of 9.1%.[2,3] Although there is no comprehensive national data regarding the prevalence of urolithiasis in Saudi Arabia, recent estimates point to a high prevalence, ranging from 6.2% to 11.2% of urolithiasis in the Saudi Arabian population.[4-6] The comparison with earlier studies conducted in Saudi Arabia also indicates a rise in the prevalence of urolithiasis.[7] Another study reports a lifetime incidence of kidney stones in the Middle Eastern population, reaching up to 25%.[8] This high prevalence suggests that environmental, nutritional, and genetic factors can increase the risk of developing urolithiasis. Hence, there is a need for local guidelines that address incorporate identity.

Around 85% of the renal stones in the Saudi Arabian populations were calcium oxalate stones, with a similar percentage in both males and females.[9] Given the burden of this disease in the Saudi people, any person presenting with flank pain with vomiting and fever must be evaluated for kidney stones by eliciting a detailed history and examination focused on renal stones, family history of renal stones, previous history of renal stones, etc. It is also important to note that some patients with renal stones are asymptomatic.[10] The metabolic causes of renal stones are more common in children than in adults. Children may present with abdominal pain, colic, or macroscopic hematuria. Hence, the diagnostic evaluation should be rigorous to rule out such conditions, which can cause severe renal morbidity in the future.[8]

In these guidelines, we sought to provide a comprehensive review of urolithiasis. We address the diagnosis and evaluation in adults and children, nonsurgical management, metabolic workup and prevention, surgical management, and special situations. We also addressed some emerging technologies such as thulium fiber laser (TFL), endoscopic combined intrarenal surgery (ECIRS), and simultaneous bilateral endoscopic surgery (SBES). We discussed their possible effect on future practice.

Radiological evaluation of patients with renal stones [Figure 1]

- Recommendation 1: The panel suggests evaluation with noncontrast computed tomography (NCCT) of the abdomen and pelvis for patients suspected of renal colic, compared with ultrasound (USG) with or without plain films (conditional recommendation and moderate certainty)
- Recommendation 2: For patients with a body mass index (BMI) <30 suspected of renal colic, the panel suggests evaluation with a low-dose NCCT compared with conventional dose NCCT (conditional recommendation and moderate certainty)
- Recommendation 3: For patients with renal colic, when computed tomography (CT) is not available, the panel suggests an abdominal USG with or without KUB compared with KUB alone or intravenous pyelogram (IVP) (conditional recommendation and low certainty)
- Recommendation 4: For pregnant patients or children suspected of renal colic, the panel suggests abdominal USG compared to NCCT or other imaging modalities (conditional recommendation and low certainty).

Explanation: The panel placed a higher value on reducing radiation exposure and a lower value on sensitivity and specificity.

- Recommendation 5: For pregnant patients or children suspected of colic with nondiagnostic initial imaging for whom management decisions depend on identifying the presence of stone, the panel suggests that a low-dose NCCT be obtained compared to standard dose NCCT (strong recommendation and low certainty).

Explanation: The panel placed a higher value on reducing radiation exposure and interpreted a trivial difference in diagnostic ability between low-dose and standard-dose NCCT for diagnosing nephrolithiasis.

Background - Imaging for renal colic

Patients presenting with renal colic and suspected kidney or ureteric stones should be evaluated with abdominal and pelvic NCCT.[11] We placed a higher importance on diagnostic test accuracy and a lower priority on cost. Most patients presenting with renal colic in Saudi Arabia would have access to this diagnostic modality and would accept the intervention.

NCCT has a sensitivity of 94%–100% and a specificity of 97%, which is superior to alternate modalities for the diagnosis.[11-13] In addition, NCCT provides important stone information, including location, size, density, chemical composition, patient information such as skin-to-stone distance, presence of obstruction (hydronephrosis or hydroureter), and the existence of other nonurologic conditions that might cause a similar pain.[14,15]

- USG should be considered the second-best investigation as it is easy to perform, less expensive, and does not have the risk of radiation exposure. It provides good information regarding the kidney (sensitivity 88% and specificity 45%), but most of the ureter is frequently not visualized (sensitivity 45 and specificity 94%)[16,17]
- Intravenous urography (IVU) was the historical diagnostic modality for the radiological evaluation of stones before evidence supporting the efficacy of NCCT emerged. IVU can detect nonopaque stones and provide information about renal function, the degree and level of obstruction, and other causes of renal pathology causing renal colic.[18,19] The use of IVP may be appropriate in exceptional circumstances but not systematic for most patients
- KUB can detect radio-opaque stones, such as calcium stones >3 mm, while they cannot detect radiolucent stones, such as uric acid stones. As such, lower sensitivity[20] limits its use as a single modality for most patients. It may be appropriate in specific patients with known stones that can be visualized with an X-ray
- KUB has the advantage of very low radiation exposure (0.5–0.9 mSv) compared with NCCT (3.7 mSv), so it can be used to follow-up patients on whom surgery has been done or treated conservatively[21]
- A combination of KUB and USG can improve sensitivity in patients for whom radiation exposure is a concern due to pregnancy or those requiring repeated evaluations[22,23]
- Low-dose NCCT has the advantage of reducing radiation exposure and has a sensitivity equivalent to NCCT for diagnosing ureteral stones ≥2 mm.[24] Low-dose NCCT has been found to have a high sensitivity for the detection of ureteric stones in persons with BMI <30 kg/m^2.[25] It is particularly useful in selected pregnant women and pediatric cases. However, it is limited by its capacity to detect small stones and its utility in obese patients.

Imaging in pregnancy

- As exposure to ionizing radiation is contraindicated in pregnancy, owing to the danger of teratogenic effects, NCCT is not recommended in pregnant females[22]
- Low-dose NCCT can be used only in indicated cases among pregnant women to avoid radiation exposure[26,27]
- X-ray has a limited role and should be avoided during pregnancy
- USG is the gold standard diagnostic tool to evaluate a pregnant woman with renal colic. However, the presence of hydronephrosis should be read with caution as it could be pregnancy related.[28] Magnetic resonance imaging could be used as a second-line investigation in pregnant women presenting with renal colic to assess the level of the obstruction.[26]

Imaging in children

- KUB imaging helps identify radio-opaque stones and can be helpful in follow-up and treatment progress
- USG is recommended as the preferred imaging modality in children with a sensitivity of 76% and specificity of 100%.[29] It is helpful for the easy detection of hydronephrosis and for identifying some anatomical aspects of the urinary tract. It can show the ureteral jet and the grade of obstruction
- Nonetheless, like in adults, the USG does not provide information about renal function and ureteral obstruction by stones[30]
- Low-dose CT protocols are recommended in children to reduce radiation exposure
- Magnetic resonance urography cannot detect renal stones, but can be utilized in evaluating hydronephrosis and other obstructive uropathies.[31] It is worth noting that anatomic anomalies and metabolic disorders have been the two important etiological factors for childhood urolithiasis in the region.[32,33]

Laboratory investigations in the acute setting

Note: For metabolic evaluation and secondary prevention, see Section 4

- Recommendation 6: For all patients suspected of renal colic, the panel recommends a basic laboratory workup, including a urine sample for complete urinalysis and blood sample for complete blood count (CBC) and electrolytes should be completed (clinical principle)
- Recommendation 7: For patients in whom an active intervention is planned (i.e., shock-wave lithotripsy [SWL], ureteroscopy, or percutaneous nephrolithotomy [PCNL]), the panel suggests completing a coagulation profile (clinical principle)
- Recommendation 8: For patients who present with a stone that has passed spontaneously, the panel suggests sending the stone for the analysis (clinical principle).

Background – Laboratory investigations for patients with nephrolithiasis in the acute setting

Urine

- Urinalysis: Routine urine investigations such as microscopy dipstick tests are recommended for all patients presenting with renal colic or known to be having renal stones
- Urine culture and sensitivity: Patients presenting with symptoms and signs suggestive of urinary tract infection should perform urine culture and sensitivity tests.

Blood

CBC should be performed routinely in patients with renal colic. Serum blood samples for urea, creatinine, sodium, potassium, uric acid, and calcium should be done. A coagulation profile (prothrombin time, partial thromboplastin time, and international normalized ratio) should be done if any intervention is planned.

Stone analysis

- If a patient presents with a stone that has passed spontaneously, it can be helpful to send this for the analysis. Stones can be composed of uric acid, cystine, and struvite, indicating specific concomitant metabolic or genetic anomalies that can guide management planning and prevention of further recurrence[34]
- If serum calcium is high or on the higher side of normal, primary hyperparathyroidism (HPT) should be suspected, and parathyroid hormone level should be assessed
- If cystine crystals are detected on the urinalysis or stone analysis showing cystine or a family history of cystinuria, then a 24-h urine cystine should be done.[35] *The metabolic evaluation is discussed in detail in Section 4*.

SECTION 2 - MEDICAL MANAGEMENT OF UROLITHIASIS

This section reviews the medical management of urolithiasis and presents guidance on pain relief, medical expulsive therapy (MET), and chemolysis. For a discussion on secondary prevention, see Section 4.

Medical management of urolithiasis

Pain relief [Figure 2]

Pain relief for patients with renal colic is essential to good clinical practice. The choice of agent can be complicated for a given patient depending on their specific medical history and comorbidities. In particular, renal dysfunction, hepatic dysfunction, concurrent medications, and addictions can strongly influence a preferred regimen for a given patient. Consequently, the panel felt that it was essential to provide the general principles of pain management for renal colic but did not seek to assess analgesia pathways systematically. Surgical management is the following sequential pathway step when medical pain management is inadequate.

In general, we present an illustrative pathway that aims to reduce the side effects from narcotics while balancing the efficacy of analgesia by adding sequential agents when analgesia is ineffective for a given patient.[36-42]

Medical expulsive therapy for ureteric urolithiasis

- Recommendation 9: For patients presenting with ureteric nephrolithiasis <1 cm elected for expectant management, the panel suggests using MET with an alpha blocker over observation alone (conditional recommendation and moderate certainty).

Explanation: The panel placed a higher importance on a small uncertain benefit in the stone passage than on minor incidences of harm. We acknowledge a close balance of benefits and harms and reiterate the importance of shared decision-making for this intervention.

Background - Medical expulsive therapy

- Several drug classes, such as alpha-blockers, calcium channel blockers, and PDEI-5, have been investigated for MET[43-49]
- There is considerable controversy about using MET to facilitate stone passage. The committee reviewed all evidence in this matter and found a lot of discussion and opposing studies. Nonetheless, given the available data and weighing harms and benefits, the committee suggests that MET using alpha-blockers might facilitate the passage of distal ureteric stones >5 mm and <10 mm[50,51]
- There are few studies of MET as off-label expulsive therapy for children with stones, showing conflicting results.[46,52,53]

Chemolysis of urolithiasis

- Recommendation 10: In selected populations of patients with known uric acid stones, the panel suggests the use of chemolysis compared to observation only (conditional recommendation and very low certainty).

Explanation: The panel believes that a minority of selected clinical situations may benefit from oral chemolysis. However, the majority of patients who form stones would not benefit either because of stone type or size. Similarly, the panel recognizes that there is very limited evidence for efficacy and harms. We emphasize the importance of shared decision-making in this context.[54-56]

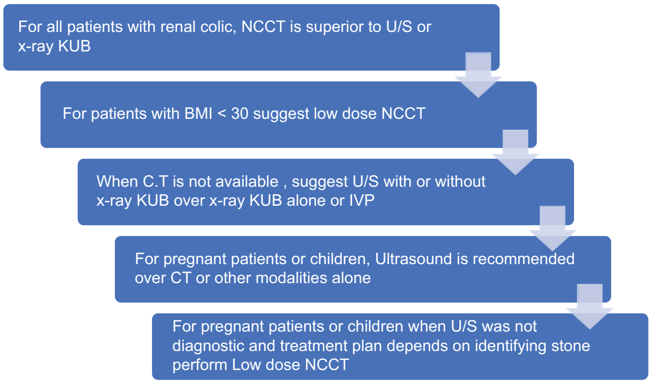

Figure 1: A proposed pathway for evaluating renal colic

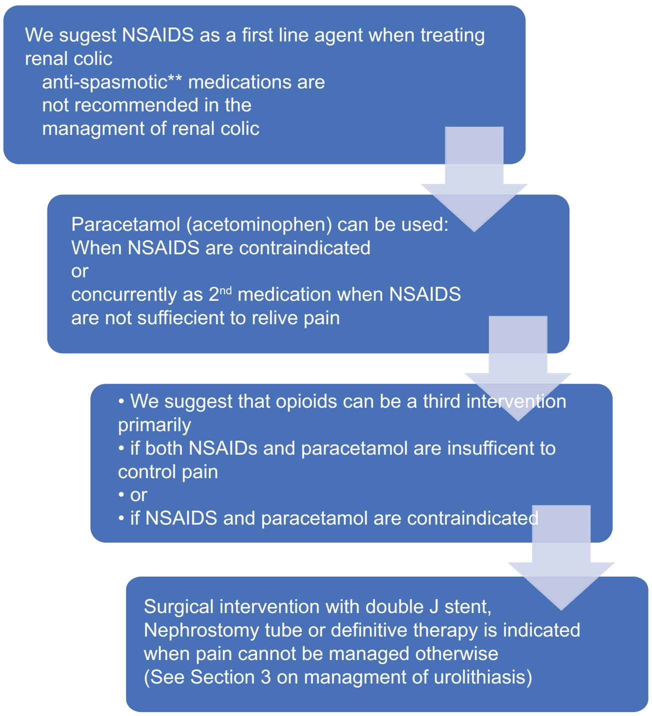

Figure 2: Illustrative analgesia pathway for patients with renal colic

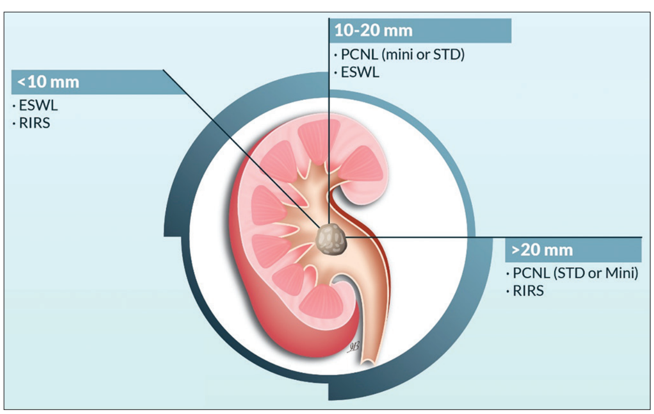

Figure 3: Algorithm for the surgical management of renal (non-lower pole stones)

Background - Chemolysis

In the contemporary setting, chemolysis refers to using an oral alkalizing agent to dissolve a uric acid stone. Historically, percutaneous approaches to chemolysis were used. However, these have been largely abandoned.[54-56] No randomized controlled trials are demonstrating the efficacy of oral chemolysis. However, in selected settings, oral agents such as citrate salt (potassium or calcium citrate) or sodium bicarbonate have been used to alkalinize urine to a pH of 7.0–7.2.

Settings in which oral chemolysis have been used are as follows:

1. In patient with renal or ureteric stone, in the absence of symptoms or obstruction
2. In patients with renal or ureteric stone causing obstruction, in the presence of renal decompression with double J stent or nephrostomy
3. For patients with small residual uric acid stones after surgery
4. For the prevention of recurrence of uric acid stones.

The important limitations in the use of oral chemolysis are as follows:

- Can only be considered when the diagnosis of uric acid stone is highly probable. Limitations to the assumption of stone type based on Hounsfield units on CT or the inability to see stone by KUB remain questionable
- It is unclear how long dissolution may take
- Maintaining a high pH over 7 may also encourage the formation of calcium phosphate stones
- Oral chemolysis for uric acid is based on urine alkalinization by applying alkaline citrate or sodium bicarbonate. Patients will need to adjust the dosage of alkalizing medication by self-monitoring the pH of their urine, which should be adjusted to 7.0–7.2[57-59]
- Monitoring radiolucent stones during therapy is the domain of the US; however, repeat NCCT might be necessary.[57-59]

SECTION 3 - SURGICAL MANAGEMENT OF UROLITHIASIS

This section discusses the indications and management options for asymptomatic and symptomatic stones. We divide the presentation of management options anatomically, considering renal and ureteric locations separately. We close with an explorative discussion of new approaches in surgical management and propose an algorithm for the surgical management of renal and ureteric stones.

Management of renal urolithiasis

Management of asymptomatic stones

Note: Recommendations 11–13 refer to "intervention" without specifying which surgical intervention. Discussion on the choice of surgical intervention is reviewed in subsequent Section 3.2.

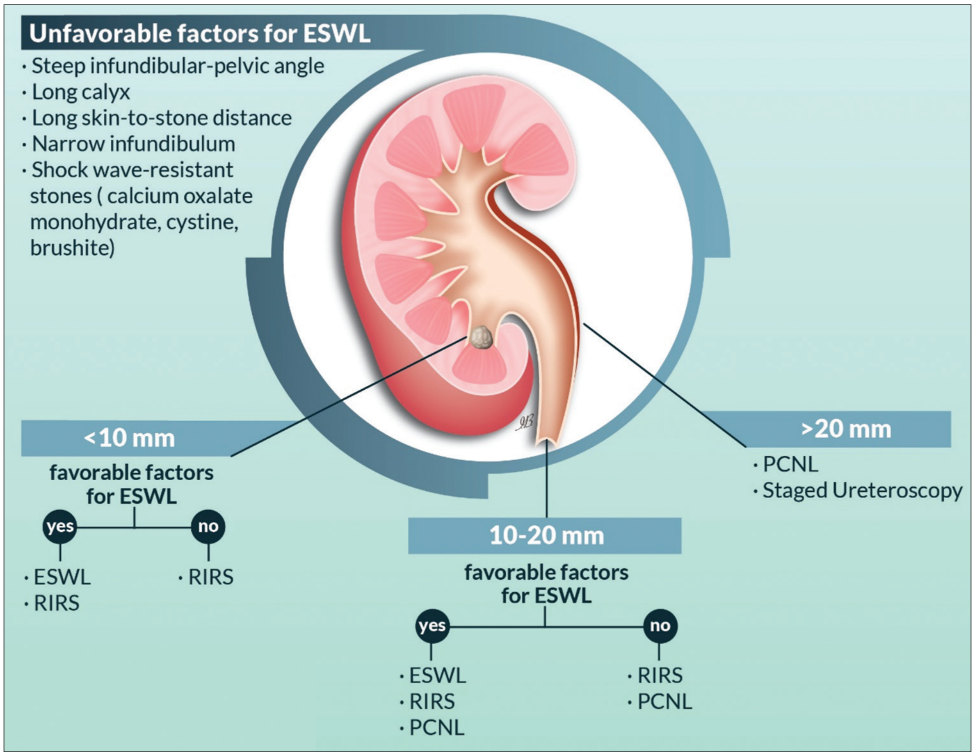

Figure 4: Algorithm for the surgical management of lower pole stones

- Recommendation 11: For patients with asymptomatic renal stones causing kidney obstruction, the panel recommends surgical intervention when there is a low expectation of spontaneous passage compared to surveillance only (strong recommendation and moderate certainty).

Explanation: The panel placed a high value on reducing unwanted effects from prolonged renal obstruction over potential harm and cost of intervention. Expectations of spontaneous passage will primarily be based on stone size. The panel considered a 10-mm stone or larger as unlikely to pass and a 5-mm stone or smaller as very likely to pass. For stones between 5 and 10 mm, the panel infers a gradient in the likelihood of passing a stone with considerable uncertainty for any given patient. The optimal observation timeframe in which a clinician decides whether a smaller stone is likely to pass is still being determined. The panel considered a stone that has not passed for a duration of 4–6 weeks of observation is unlikely to pass. This inference was based on the observation periods commonly used in trials of MET. Other assumptions for the recommendation include that the patient was medically fit for surgery and had a viable kidney. In the less common circumstance of prolonged obstruction with evidence for severe loss of function, recommendation 11 would not apply.[60,61]

- Recommendation 12: For patients with asymptomatic (non-staghorn) renal stones and no kidney obstruction, the panel suggests surveillance as the initial management approach compared to surgical intervention (conditional recommendation and low certainty).

Explanation: The panel placed a higher value on reducing the incidence of harm and cost from surgery and a higher value on decreasing the number of interventions for patients who form stones. We acknowledge that this decision will be more sensitive to patient factors and some stone factors. Most patients with small stones <1 cm and no symptoms can be safely observed for other indications for intervention. Similarly, the majority of patients with nonobstructing stones larger than 1 cm may also be safely observed. The panel recognizes a general consensus between existing guidelines that there may be more benefit of treating stones of larger size. However, this position is based on lower certainty evidence, and we believe this factor should not override patient preferences. It may be the appropriate course to proceed with intervention rather than surveillance if this aligns with patient preferences, in particular with larger stone sizes. However, the panel believes this should not occur as the initial step for most patients.

- **Recommendation 13:** For patients with asymptomatic renal stones and no obstruction of the kidney who are undergoing surveillance with meaningful evidence of stone growth (>3 mm change), the panel suggests intervention as compared to surveillance (conditional recommendation and very low certainty).

Explanation: The panel recognizes that the primary factor in this decision will be patient preferences. In suggesting intervention in this situation, the panel places a higher value on the expected benefit of stone-free rate and reduced complications, nor the need for more invasive intervention when treating a growing stone at a smaller size compared to further observation and risk of progression to very large, obstructing or symptomatic stone. The panel also recognizes that the optimal size cutoff for intervention or progression to more invasive intervention is less well-defined and will partly depend on the surgeon's ability and access to technology.

Principles of stone surveillance

Globally, there has yet to be a consensus about the preferred frequency and type of imaging for patients undergoing surveillance.

One approach adopted by our panel suggests imaging with USG or noncontrast CT, initially at 6 months, then yearly.

The duration of observation will depend on patient preference and may be influenced by the occurrence of new stones or episodes of colic during the surveillance period.

Surveillance can be discontinued if there is minimal change over several imaging or when the burden of follow-up outweighs the benefit of surveillance for a given patient.

Background on the management of asymptomatic stones

- With the increased rate of radiographic imaging for various medical conditions, the incidental finding of renal stones has increased[60]
- The natural history of asymptomatic renal stones is unclear
- The risk of the symptomatic episode can reach up to 59.4%[60]
- Stone size and location can predict stone-related events[61]
- Review of the existing guidelines reveals a lack of consensus about when to treat asymptomatic stones. This uncertainty is likely related to the heterogeneous reporting of stone size, follow-up duration, and management indication.[61]

The indications of surgical intervention

These factors can help to inform a discussion with a patient in the clinical setting as commonly described in the literature and existing guidelines.

- Obstruction caused by stones
- Stone growth (typically not well specified)
- Stone associated with infection, which usually constitutes a urological emergency requiring urgent stent or nephrostomy placement.
- Symptomatic stones (e.g., pain or hematuria)
- Stones >15 mm
- Patient preference
- Social situation of the patient (e.g., profession or traveling)
- Inability to control pain medically.

Surgical management of renal urolithiasis [Figure 3]

Shock-wave lithotripsy

- Recommendation 14: For patients who select SWL for the treatment of urolithiasis, we recommend no routine stenting as compared to placing a stent preoperatively (strong recommendation and moderate quality evidence).

Explanation: The panel suggests that there is a negligible increase in efficacy with routine prestenting, and this procedure adds a small risk of infection and postoperative symptoms. Routine stenting also increases the burden of care since it typically entails a second procedure to remove the stent afterward. The panel placed a higher value on avoiding unwanted effects of the stent and a lower value on prophylaxis for steinstrasse.

Note: This recommendation applies to systematic stenting per routine and is not specific for cause stenting, which may occur in the usual course of clinical practice.[62-64]

- Recommendation 15: For patients having SWL in the absence of positive urine culture or infection, we suggest using no antibiotic compared with systematic antibiotics for all patients (conditional recommendation and low certainty).

Explanation: Although systematic reviews have shown minimal benefit, these reviews have been based on low-quality trials with limited sample size and considerable heterogeneity and inconsistency.[62-64] The panel placed a higher value on reducing the burden of care and a lower value on preventing a rare complication. The panel is aware of a large contemporary clinical trial (NCT03692715) that has yet to report and hopefully will contribute substantially to future guidance on this topic.

- Recommendation 16: For patients with urolithiasis and Hounsfield unit (HU) >1000, we suggest an alternative procedure such as ureteroscopy with laser lithotripsy compared with SWL (conditional recommendation, very low certainty).

Explanation: The panel placed a higher value on a small magnitude of decreased efficacy with SWL and a lower value on a small increase in infectious complications with ureteroscopy.

Principles of shock wave lithotripsy

- The panel proposes several factors that can impact the efficacy of SWL
- Proper coupling should be achieved for adequate transportation of shock waves
- Pain control during ESWL is essential for patient well-being and may increase the efficacy of stone disintegration by decreasing the patient's movement during the procedure
- Routine use of the ramping technique by starting at low energy with a gradual stepwise increase in the intensity of shock waves is thought to help prevent renal injury
- Anatomic factors and lower pole stone location are believed to reduce the efficacy of SWL and should be the part of shared decision-making with patients when deciding on treatment choice.

Background factors affecting shock-wave lithotripsy

Factors that affect the efficacy of shock-wave lithotripsy

- Stone size: In general, stones of 20 mm or greater are associated with substantially reduced efficacy for SWL[63-66]
- Obesity: High BMI, particularly long stone-to-skin ratio, negatively affects the success rate of SWL[66-68]
- Stone density: Stones with >1000 HU density by NCCT are associated with reduced efficacy[69]
- Stone composition: Calcium oxalate monohydrate, brushite, or cystine are associated with reduced efficacy[70-72]
- Stone location: Lower pole stone location is associated with reduced efficacy[73]
- Pain control: Improved analgesia can decrease patients' movement during the procedure and enhance efficacy
- Proper coupling is the most important technical aspect when performing SWL. Low rate and slow-ramping protocols lead to a better outcome and lower complications[74]
- Anatomic factors such as long skin-to-stone distance >10 mm, steep infundibular-pelvic angle <90°, long calyx >25 mm,[75,76] and narrow infundibulum <5 mm are thought to reduce the efficacy of fragmentation.

Contraindications to shock-wave lithotripsy

- Bleeding diathesis and the use of anticoagulants[77]
- Aortic and renal artery aneurysm[78,79]
- Uncontrolled hypertension[80]
- Pregnancy[81,82]
- Untreated urinary tract infection[83,84]
- Skeletal deformity[85]
- Obstruction distal to the stone.[86]

Complications of shock wave lithotripsy

- SWL is a well-tolerated and acceptably safe procedure[87]
- The complications include hematuria, steinstrasse, renal colic, urinary tract infection, sepsis, and symptomatic hematoma[88,89]
- The most severe complication is symptomatic hematoma, which is expected to be rare and reported to occur in <1% of most series[89-91]
- Steinstrasse forms in 4%–7% of cases of SWL, with stone size being the most crucial factor in the formation of steinstrasse[88,92]
- MET may increase the rate of stone expulsion and spontaneous passage
- In treating steinstrasse, ureteroscopy and SWL are both efficient[93,94]
- As with usual urological care, the urinary system should be decompressed in case of a UTI or fever through percutaneous nephrostomy of double J stent.[95,96]

Ureteroscopy for renal stones

- Recommendation 17: For patients with renal stones under 2 cm, we suggest flexible ureteroscopic laser lithotripsy as a first-line treatment, compared with SWL (conditional recommendation and low certainty).

Explanation: The panel believes that there are comparable harm tradeoffs and comparable efficacy but in favor of ureteroscopy by a small uncertain magnitude. The choice of procedure for renal stones <2 cm may be influenced by the availability of flexible ureteroscopy as well as the availability of SWL. Stone-free rates will likely be slightly improved with ureteroscopy compared with SWL, and complications will be similar with lower bleeding risk with ureteroscopy and lower infectious risk with SWL. Evidence for efficacy, as well as complications, was insufficient or very low certainty. In this context, the panel felt that the harms were equivocal and that the benefits of ureteroscopy over SWL were small. As such, either can be appropriate depending on the clinical context, patient factors, values, and preferences.

Background: Factors affecting ureteroscopy

Various technological advancements in ureteroscopy extend its indication and popularity among urologists.[97-100]

- Unlike ESWL and PCNL, RIRS has fewer specific contraindications, although some important considerations in the context of patient preferences
- In contrast to SWL or PCNL, ureteroscopy can be performed for pregnant patients under selected

conditions when the patient is fully aware of a small additional risk of preterm labor and fetal loss. The gestational period may be an important factor in patient decision-making. In particular, late third-trimester symptoms can be treated with diversion, and the patient can defer surgery after birth if she prefers to wait
- Similarly, patients with bleeding diathesis should not undergo SWL or PCNL.[77] However, they can safely undergo ureteroscopy with an increased risk of bleeding, although this is less likely to require transfusion or other intervention[62,77]
- In case of renal stones more than 2 cm where PCNL is contraindicated, RIRS can be efficacious but may require serial procedures.[62,101,102]

Percutaneous nephrolithotomy
- Recommendation 18: For patients with renal stones over 2 cm who choose surgical therapy, PCNL is recommended over SWL (strong recommendation and moderate certainty).

Explanation: The panel placed a higher importance on the efficacy of stone therapy compared with the harms of the intervention. The panel recognizes that serious complications for PCNL are more frequent than for SWL. However, the efficacy of SWL for larger renal stones is greatly reduced, typically would require several procedures, and may be completely ineffective at stone fragmentation in a large minority of situations. Furthermore, the panel considered the incidence of steinstrass to be higher with SWL. Similarly, the panel believes there is likely an increased frequency of use of double J stent with SWL in the Saudi context, which further increases the burden of care for the patient.
- Recommendation 19: For patients with renal stones over 2 cm who choose surgical therapy, PCNL is suggested compared to planned serial ureteroscopy (conditional recommendation and very low certainty).

Explanation: The panel placed a higher value on efficacy than on harm but believes that serial ureteroscopy presents a much lower risk of harm and lower effectiveness. The tradeoff would depend on patient values and preferences and the availability of a skilled endourologist to perform PCNL. Most patients should undergo PCNL when resources are available. However, a significant minority may prefer serial ureteroscopy and should understand that more than one procedure is expected to produce comparable efficacy.
- Recommendation 20: For patients undergoing PCNL for renal stone, we recommend antibiotic prophylaxis <24 h duration compared to no prophylaxis (strong recommendation and moderate certainty).

Explanation: The panel placed a higher value on reducing the complications of infection over the minimal harms from receiving antibiotic prophylaxis for a short duration.
- Recommendation 21: Among patients undergoing PCNL with supracostal access, we recommend a postoperative chest X-ray in the upright position to assess for pneumothorax or hemothorax compared with no postoperative imaging (strong recommendation and moderate certainty).

Explanation: The panel placed a higher value on identifying a less common complication and a lower importance on cost and small additional radiation exposure. This judgment was driven mainly by the risk of a potentially severe consequence of undiagnosed or delayed diagnosis of a thoracic complication.

Principles of percutaneous nephrolithotomy
- Puncture approach can be under fluoroscopic or USG guidance depending on the preference of the urologist or interventional radiologist obtaining access
- Adequacy of the access should be assessed during PCNL to confirm the appropriate location for minimal bleeding risk
- Puncture location, supracostal or infracostal, will largely be determined by patient anatomy and stone location
- Method of puncture and prone or supine positions will also be determined by availability and surgeon preference
- Use of postoperative nephrostomy is determined by the surgeon at the time of surgery. Uncomplicated cases are where no residual fragments are left, and no planned second look can be performed without leaving a nephrostomy tube
- Miniaturized PCNL required specific expertise equipment and careful patient selection. This can be conducted with a well-informed patient
- When PCNL is contraindicated, and the patient opts for therapy, serial ureteroscopy will usually be the most appropriate choice of intervention.

Background: Percutaneous nephrolithotomy for management of renal stones
- For renal stones more than 2 cm and staghorn stones, PCNL is widely considered the first choice based chiefly on the highest stone-free rate regardless of stone size or hardness[62,64,103,104]

Table 1: Serum abnormalities and their corresponding possible pathology

Electrolyte	Blood level	Possible pathology
Calcium	High	Excessive Vitamin D Immobilization Hyperthyroidism Sarcoidosis Primary HPT
Phosphate	Low	Primary HPT
Urate	High	Gout Metabolic syndrome Malignant disease Cytotoxic treatment
Potassium	Low	Hypokalemic hypocitraturia
Creatinine	High	Nephrolithiasis Renal pathology
Bicarbonate	Low	Complete RTA

RTA: Renal tubular acidosis, HPT: Hyperparathyroidism

Table 2: Urine abnormalities and their corresponding possible pathology

Parameter	Urine level	Possible pathology
Calcium	High	Excessive Vitamin D Immobilization Hyperthyroidism Sarcoidosis Primary HPT
Calcium	Low	Intestinal malabsorption Secondary hyperoxaluria
Oxalate	High	Primary hyperoxaluria Secondary hyperoxaluria
Citrate	Low	RTA partial or complete Carbanhydrase inhibitor
Magnesium	Low	Intestinal malabsorption
Sodium	High	Lead to hypercalciuria
Phosphate	High	High phosphate intake
Cystine	High	Lead to cystinuria
Urea	High	High protein intake
pH	High	Distal RTA Infection Carbanhydrase inhibitor
pH	Low	Intestinal loss of alkali Acid load Insulin resistance

RTA: Renal tubular acidosis, HPT: Hyperparathyroidism

- Prophylactic antibiotic before PCNL decreases the risk of postoperative fever and sepsis.[105] A single prophylactic antibiotic <24 h before the procedure is considered sufficient for the low-risk group, defined as negative urine culture and no drains.[106] Nonetheless, in the moderate-to high-risk group, a 7-day prophylactic antibiotic may decrease the rate of postoperative sepsis[107]
- The puncture of PCNL can be done under fluoroscopic or USG guidance or both.[108] Some adapted technologies have been developed for PCNL puncture guidance but are not yet widely available[109]
- A urologist or an interventional radiologist can obtain a PCNL puncture. Some studies have shown improved outcomes when the urologist punctures.[110,111] The trend in Saudi Arabia is that urologists primarily obtain access[112]
- Supracostal and infracostal access are both effective. Nonetheless, supracostal access is associated with a higher rate of complications such as hydrothorax and bleeding[113]
- Amplatz dilators, balloon dilators, and metal telescopic dilators can be used to dilate the tract. There is no significant difference in the outcome and complications between devices to dilate. The choice depends on the surgeons' preference[114]
- PCNL can be done in a supine and prone position with a comparable stone-free rate and complications but is surgeon-dependent primarily.[115]

Contraindications of percutaneous nephrolithotomy

- Pregnancy
- Bleeding diathesis
- Uncontrolled urinary tract infection.[103]

Standard versus miniaturized percutaneous nephrolithotomy

Over the past few years, there has been significant interest in the miniaturization of PCNL,[116] especially with the introduction of new disintegration devices and the use of laser-in-stone disintegration tools in smaller tracts.[116,117] Studies have shown that miniaturized PCNL is associated with lower Hb drop, lower rate of transfusion, and shorter hospital stay.[118] However, a paucity of studies with direct comparisons of standard versus miniaturized PCNL in a randomized setting remain. Therefore, overall efficacy for all patients is challenging to assess. Miniaturized PCNL may be preferred in well-selected patients, depending on the surgeon's expertise. Currently, the panel believes that conclusions are not generalizable to urologists.

Laparoscopic and open surgery for renal stones

- Recommendation 22: For patients with renal stones >2 cm in size, we recommend PCNL compared to laparoscopic or open surgery (strong recommendation and moderate certainty).

Explanation: The panel has placed a higher value on reducing the harms of surgery with comparable efficacy expected from either approach. This may imply that a patient should be referred to a center offering PCNL if appropriate. In some less rare circumstances, performing laparoscopic (with preference) or open surgery for renal stone may remain appropriate. The treating team should clearly elaborate on the treatment choice in this situation and why referral would not be possible or would not help. One such example may be concurrent therapy for ureteropelvic junction (UPJ) obstruction, in which the primary surgery is to correct the obstruction, and the concurrent surgery is for the removal of nephrolithiasis.

Background laparoscopic and open surgery for renal stone

- The justifications for open or laparoscopic stone surgery have greatly diminished thanks to advancements in SWL and endourological surgery (URS and PNL)[118-129]
- Due to the abundance of urologists and centers that perform PCNLs, open surgery should be kept to the absolute minimum. If PCNL is unlikely to be effective, it is better to perform laparoscopic or robotic pyelolithotomy with a qualified urologist rather than open surgery.[118-131]

Endoscopic combined intrarenal surgery

The term ECIRS implies simultaneously combining the antegrade approach using PCNL and the retrograde approach using ureteroscopy. Initially popularized in the supine or modified supine position,[132] it was also described in the prone-split leg position.[133-135] However, the procedure requires two surgeons, instruments, and disposables for PCNL and ureteroscopies.

Possible indications are as follows:[136-143]

- Large stones or many stones in different calyces
- Large renal stone and concomitant ipsilateral ureteral stones or strictures
- Diverticular stones with a difficult angle to the infundibulum or a narrow infundibulum.
- Heavily encrusted DJ stent
- There is difficulty in approaching the angle from the calyx of the percutaneous puncture to other calyces to avoid multiple tracts
- Impacted UPJ stones with complete obstruction and ureteral strictures that require an antegrade incisional procedure.

The panel emphasizes that there is insufficient data to support the routine application of ECIRS. In addition, it should be reserved for well-equipped hospitals with a team of experienced urologists who can perform it in an experimental setting with a well-informed patient (Consensus).

Simultaneous bilateral endoscopic surgery

The acronym SBES was first described in 2018.[144] It entitles performing RIRS on one side while performing PCNL on the other side simultaneously.[145] The SBES has been shown to have comparable SFR and complication rates to staged procedures.[145] Nonetheless, like ECIRS, it requires two teams of surgeons, nurses, assistants, monitors, instruments, and disposables. Moreover, there is no sufficient data to support its safety and cost-effectiveness, and it should not be considered a standard of treatment for bilateral renal stones yet.

The panel emphasizes that there is insufficient data to support the routine application of SBES, which could not be recommended as standard practice and should be kept for highly specialized centers in an experimental setting with well-informed patients (consensus).

Endoscopic management of lower pole stones [Figure 4]

The panel believes that lower pole stones can be considered a separate category of renal stones due to decreased treatment efficacy. Conceptually, clearance is thought to be reduced with SWL since fragments might stagnate in the lower calyx rather than be cleared by gravity in other renal locations. Similarly, lower pole stones can also increase the difficulty of flexible ureteroscopy due to steep angles, in some cases dependent on renal anatomy. This can require more acute deflection angles and impair the access with a laser or a basket through the working channel.

Studies have shown a higher rate of secondary procedures when SWL is chosen to manage lower pole stones.[146-167] Urologists must keep in mind the factors that contribute to the unsuccessful outcome of SWL as described in Section 3.2.2.

Residual fragments after endourological intervention

- Recommendation 23: Indications for re-intervention after endourological surgery are the same as indications for surgery in general. Note that residual stone only is not a sufficient indication for re-intervention (clinical principle).

There is no universal definition of clinically significant residual fragments. Conceptually, a residual fragment that matters is one that may lead to another intervention. Some series have identified that fragments >4 mm were found to have an increased risk of requiring additional intervention.

Importantly, the committee emphasizes that the size of residual fragments should not be the sole determination of re-intervention. This is out of a concern for overtreatment and priority given to avoiding unnecessary surgeries until symptomatic. Generally, the indications for intervention after endourological surgery are the same as the indications of surgical intervention overall.[168]

Management of an obstructed kidney with sepsis and/or anuria

- Recommendation 24: For patients who present with clinical signs of sepsis, we recommend urgent decompression of the kidney with either ureteral stenting or percutaneous nephrostomy tube (clinical principle)
- Recommendation 25: For patients who present with clinical signs of sepsis, we recommend delaying

definitive surgery until sepsis has been resolved (clinical principle).

Principles of managing a patient with sepsis and an obstructing stone

1. Stabilize the patient with crystalloid and pressure support as needed
2. Initiate broad-spectrum antibiotics in consideration of patient allergies. Typical agents include piperacillin-tazobactam, meropenem, and imipenem
3. Urgently decompress the kidney as per recommendation 23
4. Collect urine at the time of decompression for urine culture and sensitivity
5. Re-evaluate the antibiotic regimen after sensitivities are reported
6. Consider stepping down to an oral agent according to sensitivities after the patient has been afebrile and hemodynamically stable for 48 h
7. Definitive therapy should not be attempted until complete resolution of infection and completing extended antibiotic course, typically 10–14 days after decompression.[169-171]

Surgical management of ureteric urolithiasis

Selection of intervention, ureteroscopy, and shock-wave lithotripsy

- Recommendation 26: For patients with a proximal ureter or UPJ stone, the panel suggests that either ureteroscopy or SWL can be selected, and where both are available, it should rely on patient preference and shared decision-making to determine the preferred course of action (conditional recommendation, low certainty).

Explanation: There are limited comparative studies of SWL and ureteroscopy to infer efficacy. SWL is generally thought to have the highest efficacy for stones in the proximal ureter or UPJ. Harms for SWL or ureteroscopy are generally infrequent or minor and of comparable frequency and magnitude of severity. In the absence of high-quality comparative studies, the panel did not want to limit the use of either technology. Situation-specific factors, equipment availability, and patient and physician preference in a shared decision-making context will largely determine the preferred choice.[62,64]

- Recommendation 27: For patients with distal ureteric stones, the panel suggests that ureteroscopy is preferred compared with SWL (conditional recommendation, very low certainty).

Explanation: The panel inferred a higher stone-free rate for distal stones due to the limitations in identifying distal ureter stones over the bony pelvis, with small and harms for either ureteroscopy or SWL, which are comparable in magnitude. However, either can be an appropriate intervention in some centers where SWL or ureteroscopy is unavailable.

- Recommendation 28: For patient undergoing ureteroscopy for ureteric stone, when ureteric access is not feasible intraoperative, suggest placing a double J stent for passive dilation and a second attempt at ureteroscopy after a minimum of 7 days as compared to immediate dilation of the ureter with balloon dilator or other means (conditional recommendation, very low certainty).

Explanation: The panel placed a higher value on avoiding ureteric trauma with active dilation over the burden and cost of a second ureteroscopy. The panel recognizes that dilating actively during the first surgery may be appropriate in some circumstances, such as known ureteric stricture. The panel expects that this would be in a smaller minority of cases.

- Recommendation 29: For patients undergoing ureteroscopy, stone extraction under vision is recommended over the blind basket approach (strong recommendation and low certainty).

Explanation: In this situation, the panel recognizes that the quality of available data is low. However, the panel placed a higher value on mitigating major injury from blind basketing, such as ureteric avulsion, which is felt to occur with a negligible incidence when basketing is under vision. The panel believes that it is currently inappropriate care to perform blind basket procedures to remove stones due to the imbalance of benefits and harms when compared to the alternative of basket extraction under vision.

- Recommendation 30: For patients undergoing ureteroscopy for ureteric stone, the panel recommends not routinely stenting preoperatively compared to stenting all patients preoperatively (strong recommendation and low certainty evidence).

Explanation: The panel placed a higher value on avoiding unnecessary procedures for which there lacks compelling evidence of benefit. This statement does not include patients with a secondary indication or preoperative stenting, such as for pain control or infection. A strong recommendation based on low certainty evidence is made here since the panel believes that the benefit, harms, cost, burden of care, and patient values and preferences all align with avoiding routine preoperative stenting. The panel believes that higher-quality studies demonstrating this are less likely to produce a change in the direction of recommendation.

- Recommendation 31: For patients undergoing ureteroscopy for ureteric stone, the panel suggests not routinely placing a double J stent for uncomplicated ureteroscopy as compared to routinely placing a stent (conditional recommendation and low certainty evidence).

Explanation: Uncomplicated ureteroscopy was considered ureteroscopy with no prior infection, no apparent ureteric trauma, no anatomic abnormality, functioning contralateral kidney, and no clinical suspicion of residual stone. The panel placed a higher value on avoiding additional procedures such as stent removal as well as avoiding stent symptoms over the much less common incidence of postoperative ureteral spasm or occult ureteric injury or undiagnosed infection. The panel recognizes that a small proportion of patients in this category may require postoperative stenting for pain or fever, but this is outweighed by the large majority of patients who would have fewer stent-related symptoms or discomfort with stent removal.[62,64]

Principles of ureteroscopy for ureteric stones

The choice of lithotrite during ureteroscopy will be determined by availability and surgeon knowledge. Holmium laser is the current standard. Emerging technologies such as thulium laser may have theoretical advantages but must be evaluated in comparative studies of outcomes important to patient care (Expert opinion).

Stents will depend on patient preference, surgeon experience, and case-specific clinical circumstances. For uncomplicated ureteroscopy, it is preferable not to leave a double J stent to avoid the stent symptoms and the need to remove the stent (clinical principle).

In rare situations, percutaneous antegrade removal of ureteral stones may be necessary if SWL is not available or ineffective or as per patient preference when the retrograde ureteroscopic approach is not feasible (Clinical principle).

For challenging clinical situations that require innovative approaches and advanced skills, patients should be referred to clinicians and centers with appropriate expertise (clinical principle).

Background on surgical management of ureteric urolithiasis

The growing use of URS in treating renal and ureteral stones has been attributed to technological advancements such as endoscope miniaturization, improved deflection mechanisms, higher optical quality and instruments, and the introduction of disposables.[172-175]

Indications for the active removal of ureteral stones are as follows:[176-178]

- Stones with a low likelihood of spontaneous passage
- Persistent pain despite adequate analgesic medication
- Persistent obstruction
- Renal insufficiency (renal failure, bilateral obstruction, or obstruction in a single kidney).

Practical considerations

- Even though some groups have demonstrated that URS may be performed without a safety wire, it is generally advisable to use one in the usual setting[179-181]
- If ureteral access is not feasible, a double J stent followed by URS after 7–14 days is advisable as compared to active dilation with a balloon dilator or another method. This allows for passive dilation and lower risk of trauma but requires a second surgery at a later date[182]
- Ureteral access sheaths provide convenient repeated access to the upper urinary tract, with better visibility, lower intrarenal pressure, and potentially minimized operating time.[183,184] However, this benefit must be considered in the context of potential ureteric injury, especially with larger diameter sheaths and the increased cost of disposables
- In some infrequent circumstances, such as large (>15 mm), impacted proximal ureteral calculi in a dilated renal collecting system, or when the ureter is not susceptible to retrograde manipulation, percutaneous antegrade ureteral stone removal may be considered[185-192]
- With a moderate increase in bleeding complications, ureteroscopy can be performed in individuals with bleeding disorders.[77]

Choice of lithotrite for ureteric stones

- The most common lithotrite used for ureteroscopy is the holmium:yttrium-aluminium-garnet (Ho:YAG). This laser is the standard due to its efficiency and safety.[193] Holmium laser can effectively fragment all stone compositions and produce smaller fragments when compared to older modalities such as electrohydraulic lithotripsy or pneumatic lithotripsy[194-202]
- The TFL is a newer, generally safe laser technology in endoscopic lithotripsy[203]
- When we compare the characteristics of TFL with Ho:YAG laser, the TFL is a more flexible fiber (TFL fiber is as small as 150 μ while the smallest Ho:Yag fiber is 200 μ). TFL seemed to fragment twice as fast

in a laboratory setting, with less retropulsion, and demonstrated greater ablation efficiency than the Ho:YAG laser[204-206]
- The theoretical benefit of the TFL is the ability to use very low energy and high frequency, resulting in finer stone dust. Further clinical trials are required to demonstrate these theoretical benefits and address the safety and efficacy of TFL.

Ureteral stenting
- Routine stenting before SWL is not believed to improve the stone-free rate or prevent complications[207-210]
- Stenting can be considered if definitive intervention will be delayed more than 4–6 weeks[211]
- In contrast, there is some low-certainty evidence that there may be some benefit to stenting before ureteroscopy. To a small degree, this may facilitate ureteroscopy, improve the stone-free rate, and reduce intraoperative complications. However, the small benefit must be weighed against the burden to the patient, stent symptoms, and additional cost. Given that the net benefit does not clearly favor stenting before ureteroscopy, this practice should not be done routinely[212,213]
- The ureteral stent is typically removed after 1–2 weeks
- Alpha-blockers can be used to improve stent-related symptoms.

Uncomplicated ureteroscopy can be without a postoperative stent.[214-216]

A ureteroscopy can be considered uncomplicated if all the following conditions are met:
- No ureteric injury
- No ureteric stricture or an anatomical abnormality affecting stone fragments passage
- Normal contralateral kidney and normal renal function
- No planned second look
- Patients should be informed about the possible complications of omitting JJ stent insertion postureteroscopy.

Management of urolithiasis in special cases
Management of stones in pregnant patients
- Recommendation 32: For pregnant patients with small stones that are expected to pass spontaneously, observation is the preferred initial clinical approach (clinical principle)
- Recommendation 33: For pregnant patients with obstructing stones that are unlikely to pass or stones with poorly controlled pain, the choice of intervention should focus on patient values and preferences in consideration of gestational age (clinical principle).

Principles of stone management in pregnancy
- Management of ureteral stones is conservative as the first-line therapy, and the patient should be followed closely to monitor the symptoms[217]
- If conservative measures are inadequate, three options may be appropriate, including ureteral stenting, placement of percutaneous nephrostomy tube, or ureteroscopy. Largely, the decision will be determined by patient preference in consideration of the risk of anesthesia, including congenital fetal malformation, spontaneous abortion, and premature labor.[218] As well as symptoms associated with a double J stent or nephrostomy tube and the frequency with which these will need to be changed relative to gestational age[28,219]
- For example, a mother in the third-trimester may prefer a double J stent or nephrostomy if this does not have to be changed until after delivery when definitive stone management can be achieved without risk to the baby. In contrast, a patient may elect ureteroscopy earlier in gestation if the alternative is to have several stent or nephrostomy changes during pregnancy
- The panel believes there will be variation in risk tolerance for complications to the fetus among pregnant patients. However, we believe that a large proportion of women will place a very high priority on avoiding fetal complications. As such, this issue should be central to any management discussion for pregnant women with renal colic
- The tradeoff of intervention versus observation should also consider narcotic use and potential effects on maternal and fetal health
- NSAIDs should generally be avoided during pregnancy and may limit the efficacy of a conservative management approach for some women
- SWL is contraindicated in pregnancy
- The panel suggests that avoiding PCNL during pregnancy is preferable[220-222]
- Whenever possible, using USG guidance for ureteroscopy or ureteral stenting during pregnancy is preferred. Fluoroscopy guidance is also acceptable with fetal shielding and pulsed imaging and an effort to reduce radiation exposure[26]
- The second trimester is considered the safest time for ureteroscopy relative to fetal complications. Consideration may be given to the age of fetal viability when choosing to intervene. The Ho:YAG intracorporeal lithotripter appears safe during pregnancy.[223,224]

Management of stone in a pediatric population
- Recommendation 34: For pediatric patients with small stones that are expected to pass spontaneously,

observation is the preferred initial clinical approach compared with immediate surgical intervention (clinical principle)

- Recommendation 35: For pediatric patients with obstructing stones that are unlikely to pass or with poorly controlled pain, the choice of intervention may include ureteroscopy or SWL in consideration of the size and age of the child in the context of the values and preferences of the patient and their parents (clinical principle).

Principles of stone management in the pediatric population

- The incidence and prevalence of urinary stones in the pediatric age group are increasing. Hypercalciuria and hypocitraturia are the most common abnormalities associated with urolithiasis in children[225]
- Observation is preferred for ureteral stones <10 mm with or without expulsive medical therapy MET as the first-line management[226-228]
- MET is likely safe for the pediatric age group, with limited data on both safety and efficacy[228]
- For patients with smaller anatomy and concern about accommodating ureteroscopes, shock-wave lithotripsy is the preferred first-line intervention. As in adults, the efficacy of SWL is thought to be reduced with stones more than 10 mm, impacted stones, calcium oxalate monohydrate, or cystine stones[229]
- Children may have better results with general anesthesia for SWL. SWL can also be performed under sedation or analgesia, especially in older cooperative children[230]
- Ureteroscopy is increasingly used in children with ureteral stones with good efficacy, and some series document a stone-free rate of up to 98%
- Both SWL and URS are appropriate treatment choices for children with ureteral stones who are unlikely to pass the stones or who have failed conservative management.[51-53,231-235]

Management of stones in urinary diversions

- Recommendation 36: For patients with symptomatic urolithiasis and a urinary diversion, we suggest initial management for pain or infection control with a percutaneous nephrostomy tube compared with a double J stent (Conditional recommendation, very low certainty)
- Recommendation 37: For patients with urolithiasis and a urinary diversion requiring definitive management, we recommend referral to an experienced endourologist (clinical principle).

Patients with urinary diversion are at risk for developing urolithiasis. This is thought to be due to metabolic factors, infections, foreign bodies, mucus secretion, and urinary stasis.[236,237] A metabolic evaluation and medical management of metabolic abnormalities can be considered to prevent stone formation and recurrence. Appropriate therapy for symptomatic urinary infection and regular irrigation of reservoirs can help reduce stone formation. Some series suggest irrigation twice weekly with 240 ml saline and once weekly with gentamycin;[238] however, there is no optimal approach nor comparative studies of intervention for the prevention of stone formation.

Surgical intervention with SWL may be advantageous over ureteroscopy as initial management in patients with small symptomatic stones in the upper ureter or kidneys for whom observation is insufficient.[239] Retrograde endoscopic approaches can be attempted with reduced efficacy due to challenges to access the ureter.[240] The percutaneous antegrade approach for ureteral stones is appropriate when SWL has been unsuccessful or is unavailable. The anterograde technique may benefit from minimal dilation and a short access sheath (12/14 Fr) to facilitate an advancing flexible ureteroscope.[94] However, this approach should preferably be performed by an experienced endourologist using the specific techniques they are most familiar with.

Management of stones in a transplanted kidney

- Recommendation 38: For patients with symptomatic urolithiasis and a transplanted kidney, we suggest initial management for pain or infection control with a percutaneous nephrostomy tube compared with a double J stent (conditional recommendation and very low certainty)
- Recommendation 39: For patients with urolithiasis and a transplanted kidney requiring definitive management, we recommend referral to an experienced endourologist (clinical principle).

Patients with transplanted kidney rarely present with typical renal colic. They are commonly present with decreased urine output, renal impairment, urine infection, or mild abdominal pain.[240,241] Additional considerations that impact treatment choice for this population include that patients have a solitary kidney, are on immunosuppressant medications, and may have abnormal anatomy of the reimplanted ureter.[242,243] Typically, obstruction requires an urgent nephrostomy or ureteral stent. Of the two interventions, nephrostomy is likely more feasible for most patients since cannulating a reimplanted ureter may be challenging.[244]

Conservative management can be appropriate in select circumstances, for a short duration of time, in a supervised setting among well-informed patients with stones small enough that they are expected to pass with high probability. The threshold for intervention should be very low, and renal function and urine output should be monitored.

Definitive management often requires advanced endourological techniques, and whenever possible, the patient should be referred to an experienced endourologist. Ureteroscopy can be done retrogradely with difficulty due to the localization of ureteric insertion in the bladder. When a patient already has a nephrostomy tube, this can facilitate an anterograde approach to definitive management, or it may be used to direct a wire into the bladder to facilitate a retrograde ureteroscopic approach.[245,246] Notably, the transplanted ureter generally lacks soft-tissue support, which may increase perforation risk.[245-247]

SECTION 4 - METABOLIC EVALUATION AND PREVENTION OF RECURRENCE OF UROLITHIASIS

General considerations for patient evaluation

- Recommendation 40: For all patients who form stones, we suggest adhering to the following principles of initial evaluation compared to no specific approach (clinical principle).

Principles of initial evaluation for patients with urolithiasis

- When a stone fragment is available, it should be sent for the analysis of the composition.

Explanation: Some stone compositions can lead to preferred pathways of evaluation and prevention. For example, uric acid stone composition may favor urinary alkalization for some patients, or patients with brushite stone composition should undergo further metabolic evaluation.[248]

- Serum electrolyte and calcium, urine pH, and microscopy reports should be evaluated to identify stone type and preventative strategies[249-251] See Tables 1 and 2 for serum and urine abnormalities and their corresponding possible pathology.
- Radiological characteristics of the calculi on X-ray or noncontrast CT KUB should be evaluated to identify stone type and preventative strategies.[249-251]
- Recommendation 41: For all patients who form urolithiasis, we suggest adhering to the following the principles of prevention compared to no specific approach (clinical principle).

General principles of prevention of urolithiasis

- Increase fluid intake quantity to bring urine output to 2.0–2.5 L/day. Explanation: This may require 2.5–3.0 L/day consumption but will vary based on individual activity level and external conditions that increase fluid loss, such as a hot environment[252,253]
- Balanced diet (rich in vegetables and fiber-normal calcium content: 1–1.2 g/day-Limited NaCl content: 4–5 g/day-Limited animal protein content: 0.8–1.0 g/kg/day), a diet rich in vegetables increases the urine pH and hence decreases the recurrence of stones[252-255]
- Lifestyle counseling to maintain a regular BMI level - Sufficient physical activity - Compensation for excessive fluid loss[254-255]
- The panel recognizes that the magnitude of impact for dietary and activity modification is likely small and supported by very low certainty evidence. However, the harms are thought to be negligible, and there may be additional cardiovascular benefits overall.
- Recommendation 42: For patients with frequently recurrent stones, pediatric age group, and brushite stone composition, solitary kidney, renal impaired patient, postbowel resection or bariatric surgery and inflammatory bowel disease; we suggest a complete metabolic evaluation (see suggested metabolic evaluation) over observation only (conditional recommendation, low certainty).[69-81]

Explanation: Some patients may benefit from additional metabolic evaluation, but not all patients who form stones. When a complete metabolic workup is completed for an indiscriminate population of all stone formers, the great majority of evaluations do not identify a modifiable cause aside from low fluid consumption. All patients should be advised on fluid consumption; additional testing to document low consumption is not mandatory. The ideal selection criteria that would increase the probability of identifying a correctable abnormality have not been systematically established. Patients with one or more of the following commonly receive further metabolic work-ups at a younger age (pediatric): Bilateral stones, brushite stone composition, and frequent recurrence.[249-251,256,257]

Suggested metabolic evaluation

- 1 or 2 24-h urine collections obtained for total volume, pH, calcium, oxalate, uric acid, citrate, sodium, potassium, and creatinine
- Serum electrolyte and calcium, urine pH, and microscopy[258]
- Parathyroid hormone (PTH) level as part of the screening evaluation if primary HPT is suspected. In

cases where PTH is evaluated perform serum Vitamin D level.[258]

Background on metabolic evaluation and prevention of urolithiasis

- Stone analysis is essential for understanding the pathology behind stone formation and in some instances, can help to prevent recurrence by managing the cause and giving specific pieces of advice on dietary modifications[248]
- Most guidelines suggest that stone type is the determining factor for further diagnostic tests and prevention. The stone types include calcium oxalate, calcium phosphate uric acid, ammonium urate struvite (and infection stones), cystine, xanthine, 2,8-dihydroxyadenine, drug stones or stones of unknown composition[250,251,257,258]
- 24-h urine sampling: A 24-h urine collection seems beneficial for specific metabolic evaluation.[257-260]

Calcium oxalate stones

Assessment

The most important test is serum calcium level to determine if there is hypercalcemia, which might indicate HPT, which necessitates further management.[250,257,258]

- Metabolic abnormalities associated with calcium stone formation include hypercalciuria, hyperoxaluria, hyperuricosuria (15%–46%), hypomagnesemia (7%–23%), and hypocitraturia (5%–29%)[250,257,258]
- A urine pH of a constant 5.8 in the daily profile may indicate an renal tubular acidosis (RTA) if urinary tract infection (UTI) has been excluded[250,257,258]
- Hypercalciuria may be associated with normocalcaemia, which may indicate (idiopathic hypercalciuria or granulomatous disease) or associated with hypercalcemia that may indicate HPT, granulomatous disease, Vitamin D excess, or malignancy.[250,257,258]

Specific management

The general measures to decrease calcium oxalate recurrence as follows:

- Consume a daily portion of calcium-containing food (cheese and yogurt) as the calcium binds with oxalate and decreases free oxalate in the intestine[258,261,262]
- Consume foods low in oxalate[263]
- Reduce daily dietary purine with hyperuricosuria stone formers[263]
- Advice oxalate restriction if hyperoxaluria is present[265]
- Advice low-fat diet and offer alkaline citrates and calcium supplementation for enteric hyperoxaluria[266,267]
- Prescribing thiazide or alkaline citrates or both in case of hypercalciuria[257,258]
- Prescribe alkaline citrates and sodium bicarbonate for hypocitraturia[257,258]
- Advise avoidance of excessive animal protein intake, prescribe allopurinol, and offer febuxostat as the second-line treatment for hyperuricosuria.[257,258]

Calcium phosphate stones

Assessment[257,258,266-270]

- Calcium phosphate occurs primarily in two completely different minerals: carbonate apatite and brushite
- Carbonate apatite crystallization occurs at a pH >6.8 and may be associated with infection
- Brushite crystallizes at an optimum pH of 6.5–6.8 at high urinary calcium (>8 mmol/day) and phosphate (>35 mmol/day)
- Possible causes of calcium phosphate stones include HPT, RTA, and UTI, which require different therapy
- Blood analysis includes creatinine, sodium, potassium, chloride, ionized calcium (or total calcium + albumin), phosphate, and PTH (for elevated calcium levels)
- 24-h urinalysis includes the measurement of volume, urine pH profile, specific gravity, calcium, phosphate, and citrate
- In general, investigating the stone type is important, particularly in patients with calcium phosphate, as establishing the cause and treating it would lead to the absolute prevention of recurrence.

Specific therapy[257,258,266-270]

Treat HPT and renal tubular acidosis (RTA) as the causes of calcium phosphate stone formation.

- Most patients with primary HPT require surgery
- RTA can be corrected pharmacologically, including bicarbonate or alkali citrate therapy
- When HPT and RTA have been ruled out, pharmacotherapy for calcium phosphate stones depends on effectively lowering urinary calcium levels with thiazides. For infection-related calcium phosphate stones, it is essential to treat the infection.[106-110]

Uric acid and stones

Assessment[250,257,258,271-276]

- All uric acid and stone formers have a high risk of recurrence
- Uric acid nephrolithiasis accounts for approximately 10% of kidney stones and is associated with hyperuricosuria or low urine pH
- Hyperuricosuria may result from extreme diet, endogenous overproduction (enzyme defects), myeloproliferative disorders, chemotherapy, gout, or catabolism

- Low urine pH can be caused by decreased urinary ammonium excretion (insulin resistance or gout), increased endogenous acid production (insulin resistance, metabolic syndrome, or exercise-induced lactic acidosis), increased acid intake (high consumption of animal protein), or increased base loss (diarrhea)
- Uric acid stone should be suspected if the urine pH is low <5.5; the stone is radiolucent on X-ray KUB and with low HU on C. T. Moreover, this type of stone is more common in patients with type 2 DM or patients with metabolic syndrome.

Specific therapy[249-251,258,277,278]

- Hyperuricosuria may result from extreme diet, endogenous overproduction (enzyme defects), myeloproliferative disorders, chemotherapy, gout, or catabolism
- Hydration and diet are recommended as the general preventive measures
- Hyperuricosuria stone formers benefit from purine reduction in their daily diet
- Alkalization of urine with potassium citrate could be used as a treatment when intervention is not indicated. Prescribe allopurinol in patients with hyperuricosuria.

Struvite and infection stones

Assessment[257,258,279-282]

- All infectious stone formers are at high risk of recurrence
- Struvite stones account for 2%–15% of stones sent for the analysis.

The factors predisposing to struvite stone formation include neurogenic bladder, spinal cord injury/paralysis, continent urinary diversion, ileal conduit, foreign body, indwelling urinary catheter, urethral stricture, benign prostatic hyperplasia, bladder diverticulum, cystocele, calyceal diverticulum, and UPJ obstruction.

- Struvite stones should be suspected if a patient with the previous predisposing factors presents with a renal stone, high urine pH, and a culture of one of the urease-producing organisms.

Specific therapy[258,283-288]

- The treatment strategy should be the complete removal of the stone surgically, depending on the size of the stone.

Cystine stones

Assessment[257,258,289-295]

- Cystine stones account for 1%–2% of all urinary stones in adults and 6%–8% reported in pediatric studies[131,132]
- All cystine stone formers are at high risk of recurrence and CKD[133,134]
- Cystine is poorly soluble in urine and crystallizes spontaneously within the physiological pH range in urine
- The solubility of cystine is highly dependent on urine pH
- Genotyping of patients has no role in the routine treatment of cystinuria[136,137]
- The diagnosis of cystine stone should be based on the clinical suspicion if a pediatric patient is presented with urolithiasis, especially with positive consanguinity. Urine pH, urine microscopy, and stone analysis confirm the diagnosis.

Specific therapy[249-251,258,294-297]

- Management of cystine stones could be challenging due to the high recurrence rate and the stone burden
- It is recommended that the management should be multidisciplinary, including a dietician, nephrologist, and urologist[135]
- Dietary advice includes hydration, a low methionine diet, and decreasing sodium intake
- Increasing the urine pH above 7.2 with potassium citrate to increase the solubility of cystine. However, not to exceed the urine pH level above 8 to avoid the possibility of calcium phosphate stones
- Adding chelating agents such as d-penicillamine and tiopronin can reduce recurrence. However, the benefits are offset by the side effects of these medications. Due to the unfavorable side effect profile, close monitoring should be followed when these agents are used.[140-143]

Financial support and sponsorship

Nil.

Conflicts of interest

The authors certify that this submission is not under publication consideration elsewhere and is free of conflict of interest. All authors have approved this manuscript.

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