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Canadian Urological Association guideline: Management of ureteral calculi – Full-text

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Introduction

Globally, the prevalence of urolithiasis is steadily increasing, and though some regional variability exists, contemporary estimates report up to 10–12% of men and 7–8% of women now suffer from nephrolithiasis.[1-3]

Renal colic is one of the most frequent and expensive emergency department (ED) presentations.[1,2] A study comparing renal colic management patterns in two Canadian cities identified widely varying trends in care, with admission rates as high as 60%, and surgical intervention rates over 50%. Though early intervention has been purported to allow patients to return back to normal life sooner, it appears early intervention led to increased subsequent ED visits, re-admissions, and secondary procedures.[4] Another study looking at costs associated with management of acute renal colic found that an initial trial of non-surgical management was associated with lower indirect costs.[5]

The aim of this Canadian Urological Association (CUA) guideline document is to provide evidence-based consensus recommendations on various aspects relevant to the management of ureteral stones; the major topic areas included were conservative management, medical expulsive therapy, shockwave lithotripsy (SWL), ureteroscopy (URS), and special clinical scenarios (e.g., pregnancy, pediatrics).

Methods

Separate reviews of the literature were performed for each of the major topic areas. English-language publications were identified from PubMed/Medline, with a focus on recent publications since our last CUA guideline document on ureteral stones published in 2015.[6] The 2011 University of Oxford Centre for Evidence-Based Medicine Levels of Evidence grading system was used to evaluate the level of evidence of recommendations included in the document.[7] All recommendations were based on expert review of the literature and represent the consensus of all authors of this guideline document.

I. Conservative management of ureteral stones

Non-operative management remains a reasonable first-line approach for most patients presenting with ureteral stones. A 2010 meta-analysis of 37 studies demonstrated that 38–71% of symptomatic ureteral stones <4 mm would pass spontaneously.[8] As well, looking at the placebo control arms of several large randomized controlled trials (RCTs) evaluating the efficacy of medical expulsive therapy (MET), spontaneous passage rates range from 40–80% for stones <10 mm.[9-11] Clearly, an initial course of conservative management seems reasonable for many.

The urologist is often called upon in the setting of a suspected "septic stone" — conservative management is not an option in this setting. With a sufficient index of suspicion, early goal-directed therapy, including blood and urine cultures, broad-spectrum intravenous antibiotics, resuscitation, and source control is paramount. Decompression of an obstructed pyelonephritis reduces mortality[12] and avoiding delays can prevent prolonged hospital admissions.[13] The method of drainage should be tailored to the patient's clinical scenario and stone characteristics, as well as to the available resources at each center.[14,15] In the only prospective, randomized trial, patients presenting with a fever >38°C, leukocytosis, and obstructing stone <15 mm were randomized to either a ureteric stent or a nephrostomy tube (NT).[16] There were no differences in any clinical outcome evaluated, including time to defervescence, duration of hospital stay, and resolution of obstruction. Other studies have also found that timely decompression is paramount, regardless of method.[17-19] It is generally agreed that definitive treatment should not be undertaken until the obstructed system has been decompressed and the infection adequately treated. Although, there is no strong evidence as to how long to wait after initial treatment, one study recommends a minimum of seven days before definitive treatment.[20]

While patients with true urosepsis (life-threatening organ dysfunction caused by a dysregulated response to a genitourinary [GU] infection)[21] are more easily identified, accurately diagnosing pre-septic patients with a concomitant urinary tract infection (UTI) and an obstructing stone may not be as clear. Irritative lower urinary tract symptoms, hematuria, and pro-inflammatory urine/blood markers have led to inconsistent interpretation about the presence of infection and ultimately antibiotic use.[22] Many patients are inappropriately given antibiotics and there is an opportunity to improve clinical practice and antibiotic stewardship with some continued medical education initiatives.

Acute kidney injury (AKI) is present in approximately 6% of patients presenting with renal colic.[23] When significant renal impairment accompanies ureteral stones, early decompression or definitive therapy may mitigate further deterioration. Early intervention may also be indicated if the patient with a ureteral stone presents with intractable symptoms (pain, nausea, etc.) or significant frailty/comorbidities.

There is limited data supporting early surgical intervention rather than a period of initial conservative therapy, with one RCT demonstrating that early ureteroscopic management (<12 hours after ED admission) led to similar stone-free and complication rates but lower rates of postoperative stenting.[24] Two RCTs looking at early SWL (<48 hours) vs. delayed SWL (2–7 days) demonstrated earlier time to stone-free status, fewer required treatments, and perhaps lower complications in the early SWL arms.[25,26] Importantly, these studies had a high risk of bias, highlighted by the fact that spontaneous stone passage rates in the delayed intervention arms of these RCTs was only 0–5.4%.

Recommendation: Many patients with ureteral stones can initially be managed non-operatively, as spontaneous passage rates are high, particularly for smaller stones (<5 mm). Close followup is necessary for those being managed conservatively, to ensure spontaneous stone passage or to decide upon the need for timely intervention *(level 2, strong recommendation)*. **Obstructive pyelonephritis requires early goal-directed therapy, including timely decompression in an antegrade or retrograde fashion, whichever method is most expedient** *(level 2, strong recommendation)*.

Imaging

Use of computed tomography (CT) scans have increased by over 10-fold in recent years,[27] being performed in 90% of those diagnosed with urolithiasis in the acute setting, whereas ultrasonography (US) is used in less than 7% of these patients.[28] There is evidence to suggest patient gender may impact initial imaging modality selected.[29,30] A large, randomized trial comparing initial imaging modalities for renal colic presentations in the ED found most clinical outcomes were equivalent between US and non-contrast CT (NCCT) imaging, recommending initial US given the lack of radiation exposure.[28] In this RCT, USs performed by radiologists, compared to point-of-care US (POCUS) were less likely to result in followup CT scans, but did increase visit times within the ED.[31] While POCUS is convenient, it is more operator-dependent and consulting teams often have no images or formal report to review. Details founds on a NCCT are often, but not always, required for definitive stone management and followup, particular for complex scenarios.

Supplementing US with kidney-ureter-bladder (KUB) X-rays can enhance the sensitivity of detecting a ureteral stone. Studies demonstrate that combining these modalities results in sensitivity ranging from 79–100% and specificity up to 100%.[32] One study also demonstrated that the addition of a formal KUB X-ray, even when CT scout images were available, improved followup diagnostic accuracy.[33] Obtaining a KUB X-ray at the time of a diagnostic imaging in the ED is useful for not only determining stone composition, but also to track the progress of stone passage in followup.

Reduced-dose NCCT scans have been shown to maintain sensitivities and specificities from 90–97%, while preserving enough detail to identify alternate diagnoses. When assessing for stones specifically, body mass index (BMI) has been shown to be less of a concern, with >95% diagnostic accuracy and radiation doses <3.7 mGy regardless of BMI.[34] Though dual-energy CT scans have shown utility in identifying uric acid stone composition,[35] there is little additional benefit in the acute setting, as obstructing stones are not typically treated with dissolution therapy.

Overall, while adhering to as-low-as-reasonably-achievable (ALARA) radiation exposure principles, the patient's age, pregnancy status, stone history, and preceding exposure to ionizing radiation should be considered whenever ordering imaging for non-life-threatening indications. An overreliance on CT imaging has been identified and should be addressed in our practice patterns.

Recommendation: Ultrasonography with KUB X-ray should be considered the initial modality of choice for acute ureteral stones. Judicious use of CT scans, preferably low-dose, provides valuable information for management decisions *(level 1, strong recommendation)*. **While often omitted, the utility of a KUB X-ray at the time of presentation is very important for future followup and decision-making regarding definitive treatment options** *(level 4, expert opinion)*.

Discharge planning

Medical expulsive therapy (MET)

Recently, several large RCTs[11,36,37] failed to show improved stone passage rates or reduced analgesic requirements when using alpha-blockers for MET. However, several published meta-analyses[38-40] suggest overall benefit of MET for ureteral stones. Subgroup analysis data suggests this benefit may be mainly for larger (5–10 mm), distal ureteral stones.[36,37,40-42] A Cochrane review of 67 studies analyzed all studies, specifically looking at lower- and higher-quality studies. The higher-quality, placebo-controlled studies showed a benefit with MET (relative risk [RR] 1.16, 95% confidence interval [CI] 1.07–1.25), a decrease in hospitalizations (RR 0.51, 95% CI 0.34–0.77), and no significant changes in the need for intervention.[43]

Analgesia

Moving away from a reliance on opioids in acute care patients with renal colic is important and these patients have been found to do well with non-opiate analgesia.[44] In one study, 1500 adult acute care patients were randomized to intramuscular diclofenac, intravenous morphine, or intravenous paracetamol. At 30 minutes, non-steroidal anti-inflammatories (NSAIDs) were more effective in reducing pain by 50% compared to morphine, with no adverse events.[45] Another randomized trial showed protocoled non-opioid analgesia could reduce opioid requirements during initial presentation if first- and second-line interventions included NSAIDS and intravenous lidocaine. However, opioid-sparing approaches were associated with higher rates of repeat visits to the ED.[46] Discharge prescriptions can vary significantly based on the patient population and comorbidities. Accounting for important patient characteristics (e.g., post-traumatic stress disorder, anxiety/depression, chronic pain syndromes) when prescribing analgesia for acute renal colic is also important.[47,48]

Forced hydration

While there is clear utility in re-hydrating hypovolemic patients with significant nausea and vomiting, or in those with a suspected pre-renal AKI, intravenous (IV) hydration for the sole purpose of forced stone passage is not supported by the literature and should be avoided.[49]

Recommendation: The role of MET in promoting spontaneous passage is controversial, but the current literature suggests if there is any benefit, it is for larger (5–10 mm) ureteral (distal) stones. The advantages and disadvantages of MET should be discussed with the patient in a shared decision-making process *(level 1, strong recommendation)*. **The use of opioid-sparing analgesic regimens has been shown to be efficacious and opioids for management of renal colic should be minimized; patient education is paramount** *(level 1, strong recommendation)*. **Forced IV hydration for the purposes of stone expulsion is not recommended** *(level 1, moderate recommendation)*.

Renal colic followup

Unfortunately, neither resolution of symptoms nor patient reports of successful passage of obstructing ureteral stones is always confirmatory. One study demonstrated that 6.2% of patients reporting passage of a symptomatic ureteral stone had persistent obstruction on followup CT scan imaging.[50] Another study demonstrated that resolution of pain was only 79.7% sensitive and 55.8% specific for successful passage of a ureteral stone, based on followup US and KUB X-ray imaging.[51] As such, followup imaging to ensure passage of an obstructing ureteral stone is suggested. The ideal imaging modality of choice remains uncertain, but one study found that 38% of patients with a persistent ureteral stone, confirmed on ultra-low-dose CT, had neither hydronephrosis on CT nor a visible stone on the CT scout image.[52]

Data suggests the majority of patients that will pass ureteral stones spontaneously will do so within approximately one month of presentation.[11,33-34] Examining the literature on long-term renal damage and ureteral obstruction, it is difficult to elucidate an objectively safe or unsafe duration of observation for a ureteral stone where no imperative indication for treatment exists; the data is mainly from animal studies and usually involves a complete obstruction model. While degree and duration of obstruction are clearly important, other factors unique to each patient also need to be considered: poor baseline renal function, older age, male gender, and presence of certain comorbidities (e.g., diabetes) have been associated with increased risk of chronic kidney disease.[53,54]

Recommendation: Resolution of symptoms and patient-reported stone passage after a bout of renal colic do not always confirm passage of an obstructing ureteral stone.

Followup imaging is recommended to confirm stone passage *(level 3, strong recommendation)*. **The recommended duration of conservative management is unique to each patient, with multiple factors to be considered. Surgical intervention should likely be considered if a patient has not passed an obstructing ureteral stone after 4–6 weeks** *(level 5, moderate recommendation)*.

II. Shockwave lithotripsy

Despite the advances in ureteroscopes and laser technologies, SWL remains a first-line treatment option for ureteral calculi. SWL outcomes can be directly influenced by case selection, surgeon technique, and modifiable parameters to enhance safety and maximize successful outcomes. Much of the data for SWL outcomes is derived from patients with renal calculi, but these findings should be generalizable to ureteric stones, particularly for those in the upper ureter, where renal parenchyma is included in the shockwave path.

Clinical factors affecting SWL treatment success

Composition

The majority of stones are composed of calcium oxalate and most will fragment well with SWL treatment. There are certain stone compositions, such as cystine, pure calcium oxalate monohydrate, and brushite, that are more resistant to SWL and may be better served by ureteroscopic management.[55] Uric acid stones, while fragile in the face of SWL, require either the use of ultrasound or pyelography (intravenous or retrograde) for targeting during SWL.

Stone density

Stone density, as measured on NCCT scan in Hounsfield units (HU), has been shown to predict successful SWL outcomes. A crude surrogate for composition, a linear relationship exists between increased stone density and poor stone fragmentation with a threshold of 1000 HU, above which stones are less likely to be successfully fragmented.[56-60] The variation coefficient of stone density (VCSD), which is a measurement of stone heterogeneity on CT scan and reflects the crystal architecture of the stone, has been reported as a novel predictor of SWL success and may outperform HU as a predictor of success; however, further study in this measurement would be useful.[61]

Skin-to-stone distance (SSD)

A longer SSD has been associated with reduced treatment success for SWL for renal [62-67] and ureteral stones,[65] with SSD greater than 10 cm often associated with decreased stone-free rates (SFRs).

Recommendation: Stone size, location, composition, density, and SSD can help counsel patients regarding the success rates of SWL treatment. Known uric acid, cystine, and brushite stones are likely best treated with URS *(level 4, moderate recommendation)*. **Patients with ureteral stones with a density >1000 HU or SSD >10 cm have lower SFRs with SWL** *(level 2, strong recommendation)* **and shared decision-making with patients is important to balance the availability, morbidity, and efficacy of SWL vs. URS.**

Optimizing treatment outcomes

Dose escalation/pause

Gradually increasing SWL energy up to optimal dose allows for better patient accommodation to the sensation of treatment and, for upper ureteral stones, reduces renal injury by inducing renal vasoconstriction.[68-72] An alternative strategy is to pre-treat with a series of low-energy shocks, then pause treatment for a short period of time before resuming at higher-energy levels.[68]

Number of treatments

If SWL is not successful, it can be repeated, but the incremental benefit of more than two treatments for the same ureteric stone is small.[73,74] The optimal time interval between SWL treatments is unclear but can be short (2–3 days) for mid and distal ureteral stones.

Treatment rate

Several randomized trials have indicated that a lower shock rate can improve stone fragmentation, particularly for stones larger than 1 cm. The optimal treatment rate is not clear, however, studies suggest that SWL at 60–90 shocks/minute leads to better fragmentation than 120 shocks/minute, particularly for larger stones.[75-83] Most studies were performed with renal calculi, however, improved outcomes have been demonstrated for upper ureteric stones as well.[76]

Number of shocks

The optimal number of shocks has not been definitively established but requires balancing treatment efficacy with adverse effects, particularly renal damage. For upper ureteral stones, the recommended shock rate range is 2000–3500, but manufacturer's guidelines should be closely considered.[74] For mid to distal ureteric stones, where the renal parenchyma is not affected by SWL energy, treatment can safely be carried out up to 4000 or more shocks.[74] Some studies have assessed the efficacy and safety of increasing the number of shockwaves per session to >4000.[84,85]

Recommendation: Patients with upper ureteric stones should initially receive low-energy shocks, with gradual voltage escalation up to maximum energy *(level 2, strong recommendation)*. **If unsuccessful, repeat SWL can be considered but more than two treatments to the same ureteric**

stone has little incremental benefit and URS should then be considered *(level 4, moderate recommendation)*. **Patients with upper ureteric stones >1 cm or those selected for retreatment after initial failed SWL, should be treated at a rate <120 shocks/minute for optimal fragmentation** *(level 1, strong recommendation)*. **An adequate number of shocks (2000–4000 for most lithotripters) should be administered to ensure adequate treatment of ureteric stones** *(level 4, weak recommendation)*. **A higher number of shocks may result in improved SFRs, but data is limited to make this a recommendation for routine practice.**

Alpha-blockers

Alpha-blockers (most commonly tamsulosin) have been studied to assess their impact on SWL outcomes in multiple RCTs and meta-analyses.[86-95] Meta-analyses have shown improved SWL success rates,[89,94-96] time to stone passage, risk of steinstrasse,[93-96] and need for auxiliary procedures.[93] A recently published Cochrane systematic review demonstrated routine alpha-blocker therapy may result in improved stone clearance, less need for auxiliary treatments, fewer major adverse events, and a reduced stone clearance time.[97] Additional benefits with respect to pain and analgesic use are also of interest.

Stenting

Routine pre-SWL stenting is not necessary and does not improve the success rate or passage of fragments.[98-101] In fact, having a stent may impede the passage of fragments following SWL and does not appear to decrease the risk of steinstrasse or infection,[100-104] with the possible exception of steinstrasse risk for stones >2 cm.[100] Stents may be beneficial for obstructing stones, if relief of obstruction is warranted prior to treatment (e.g., obstruction with infection, renal failure, intolerable pain), and prior to SWL for stones in a solitary kidney.[105]

Recommendation: Alpha-blockers (e.g., tamsulosin) should be prescribed after SWL for ureteral stones to improve treatment success rates *(level 1, moderate recommendation)*. **Ureteral stents do not improve SFRs after SWL and do not reduce the risk of steinstrasse or infection following SWL for most patients (i.e., stones <2 cm)** *(level 1, moderate recommendation)*.

III. Ureteroscopy

Modern URS is a mainstay in the surgical treatment of ureteral stones worldwide. As a result of advancements in technology in recent decades, URS can be safely performed with high SFR and relatively low complications.

Preoperative alpha-blockers

The use of alpha-blockers prior to URS appears to improve intraoperative outcomes and patient SFR. A recent systematic review and meta-analysis comprising of 12 RCTs and 1352 patients evaluated alpha-blocker use before planned URS for the management of ureteral calculi.[106] With a median preoperative use of one week, a 61% risk reduction in need for ureteral dilatation was observed. Furthermore, the use of preoperative alpha-blockers significantly improved SFR (RR 1.18, 95% CI 1.11–1.24, $p<0.00001$), reduced operative time by an average of six minutes ($p=0.004$), and decreased patient hospital stay ($p=0.001$). Whether one week of use is optimal or simply convenient for patients was not defined. Larger, more appropriately powered RCTs may provide further direction regarding the efficacy of preoperative alpha-blockers for URS of ureteral stones.

Recommendation: Preoperative alpha-blockers may improve intraoperative and postoperative outcomes for patients undergoing URS. However, the optimal duration of preoperative alpha-blocker therapy is still uncertain *(level 1, moderate recommendation)*.

Postoperative imaging

The goal of postoperative imaging is to assess for residual stone burden and screen for ongoing obstruction. Residual stone fragments may lead to additional stone-related episodes and surgical intervention.[107,108] Some authors have concluded that in the setting of uncomplicated URS, routine postoperative upper tract imaging is not necessary.[109] Instead, they have recommended postoperative imaging indications include chronic stone impaction, significant ureteral trauma, prior renal impairment, endoscopic evidence of stricture, and postoperative pain or fever. However, silent obstruction, described as asymptomatic, persistent, postoperative obstructive hydronephrosis, has been shown to occur at a rate of 1.9–10% following URS, highlighting the importance of routine postoperative imaging.[109-111] The mean interval from URS to possible development of ureteral stricture is estimated to be 13 months.[112] While NCCT is the best modality for identifying both residual fragments and postoperative obstruction, the effective dosage of radiation and the cost of this modality have prevented its routine use post-URS. Rather, a combination of US and KUB X-ray are typically used to detect obstruction and stone-free status.

Recommendation: An US ± KUB X-ray is recommended following URS for ureteral stones *(level 4, strong recommendation)*. **In complicated cases, further imaging with NCCT can be performed.**

Ureteral access sheaths

Ureteral access sheaths (UAS) can offer numerous advantages during URS. They allow for rapid and multiple reentries into the upper tract, potentially reducing damage to the ureteroscope. UAS can also enhance visibility, decrease intrarenal pressure, and allow for drainage and elimination of dust and stone fragments.[113] The proper selection of UAS size is crucial to balancing URS outcomes. Excessive force should never be applied when using UAS. Most of the literature on UAS use during URS is related to renal stones.

In a prospective cohort analysis of 2239 patients, no significant difference in SFR was seen whether a UAS was or was not used during flexible URS (75.3% vs. 50.4%, p=0.604).[114] However, in a subgroup analysis of stones ≥10 mm, SFRs were significantly higher in the UAS group (84.9% vs. 81.5%, p<0.01). One systematic review revealed no significant difference in operative times, SFRs, or intraoperative complications with UAS use.[115] A critical drawback of these systematic reviews is that a substantial number of studies did not use NCCT to determine true SFR and as a result, the impact of UAS use on SFR after URS remains unclear.

In a study of 2239 patients treated with flexible URS, no significant difference in ureteral injuries was reported in patients treated with UAS in comparison to those without UAS.[114] Grades of ureteral injuries related to UAS were reported as low-grade injuries involving the mucosa in almost half of patients and high-grade lesions involved smooth muscle layer in 15% of patients.[116] Importantly, endoscopically detected high-grade ureteral lesions following UAS insertion do not appear to result in an increased rate of stricture.[117]

Recommendation: Current evidence suggests UAS use for ureteral stones has no significant impact on SFR nor on intraoperative complications *(level 2, moderate recommendation)*, **but may improve visualization, reduce intra-renal pressures, and facilitate fragment removal** *(level 4, strong recommendation)*.

Stenting

Ureteral stent placement prior to elective URS can facilitate UAS and ureteroscope insertion. In a recent prospective study of rigid and flexible ureteroscopes, the ureter was inaccessible in 8% of cases, necessitating the placement of a ureteral stent and delayed definitive treatment.[118] Some studies have demonstrated no clear advantage in SFR nor complication rate with routine preoperative stenting,[119,120] while others have shown routine pre-URS stenting was associated with a higher SFR for larger stones.[121-123]

The impact of post-URS stenting on SFR is not clear and meta-analyses have shown conflicting results. One recent meta-analysis found that stenting did not improve SFR nor reduce late postoperative complications after routine URS.[124] Conversely, in another meta-analysis of 22 RCTs, the SFR was significantly better in the stented group (95% CI 0.34–0.89; p=0.01).[101] In terms of the impact on stricture rate, a meta-analysis of 14 trials and 1652 patients demonstrated that post-URS stenting likely does not reduce stricture rates at 90 days (RR 0.58, CI 0.23–1.47).[125] Conversely, use of a stent has been shown to reduce unplanned medical visits post-URS.[125-127] Following UAS use, routine ureteral stenting seems to be beneficial in reducing pain and unplanned medical visits.[128,129]

Nonetheless, there are scenarios where routine post-URS stent placement is advisable: suspected ureteric injury or stricture, solitary kidney, and patient with renal impairment.

The evidence is not clear on whether use of a stent post-URS impacts opioid use,[125,130] but urinary symptoms have been demonstrated to be significantly worse with stent use.[101,124,126,131] Studies have demonstrated beneficial effects of various medications (e.g., alpha-blockers, anticholinergics, B-agonists) to ameliorate stent-related urinary symptoms.[132,133]

There is no consensus regarding the optimum duration of postoperative stenting. In an animal model, there were no histological ischemic changes in the ureteral wall 72 hours post-UAS insertion, suggesting that three days may be sufficient.[134] On the other hand, Paul et al compared ureteral stent dwell times of three vs. seven days and found that removal at three days was linked to a higher probability of obstruction-related adverse events (23% vs. 3%).[135]

Recommendation: Routine pre-URS stenting is not necessary but may facilitate UAS insertion and improve SFRs in patients with larger stones *(level 2, weak recommendation)*. **Routine stenting after uncomplicated URS is likely unnecessary** *(level 2, strong recommendation)* **but stent placement after UAS use is warranted** *(level 3, weak recommendation)*. **Stent-related symptoms following URS may be ameliorated with alpha-blocker and/or anticholinergic medications** *(level 2, moderate recommendation)*. **If access to the ureteral stone is complicated or impossible, placement of a stent and repeat URS is the safest option** *(level 5, strong recommendation)*.

IV. Comparing treatment outcomes – SWL vs. URS

Stone-free rate

Previously published literature comparing SWL vs. URS for ureteric calculi, which focused largely on efficacy and safety, guided the development of the 2015 CUA guideline recommendations. Since then, several other studies have been published, including some important data on cost-effectiveness and patient-reported outcomes. Due to the significant variation and heterogeneity of the techniques used to perform SWL and URS, it is difficult to make clear recommendations based on published literature.

For upper ureteric stones, a randomized trial of semirigid URS compared to SWL for stones <2 cm showed similar SFR (86.6% vs. 82.2%) at three months.[136] Those undergoing SWL had significantly higher re-treatment rates but after re-treatment, the need for subsequent auxiliary treatments was similar (21.1% vs. 17.7%, p<0.5). When the groups were substratified by stone size, URS produced a higher SFR for stones 1–2 cm (85.4% vs. 78.4%), though this was not statistically significant. Complication rates were also statistically similar (11.1% vs. 6.6%, p=0.21).

When dealing with distal ureteral stones, URS has traditionally been thought to produce superior results to SWL. However, several studies have demonstrated similar SFR between SWL and URS, with the caveat that SWL often required more than one treatment to achieve that same SFR.[137-140] A systematic review published in 2017 found that there was a better SFR with URS at four weeks, but this was comparable between groups at three months.[141] There were fewer re-treatments with URS, but higher complication rates. In terms of radiation doses to patients, one study showed equal amounts of radiation used for ureteral stones whether treating with URS or SWL.[142]

Costs can vary from region to region for each modality; an American study found that for ureteral stones ≤1.5 cm, the equivalency point for cost efficacy was when the SFR for SWL was <60–64% or if the chance of URS success was >57–76%.[143] For these situations, URS was found to be more cost-effective in an American system. A British cost-efficacy study was undertaken according to their National Institute for Health and Care Excellence (NICE) guidelines[144] and they concluded that for ureteral stones <1 cm, URS would be more costly even if SWL was only 40% efficacious.

Recommendation: SWL produces similar SFR to URS for ureteral stones, albeit with a higher retreatment rate and lower complication rate *(level 1, strong recommendation)*. **While local/regional cost models need to be considered, SWL may be a more cost-effective option for ureteric stones** *(level 4, weak recommendation)*.

Patient-reported outcomes

Ureteral stones can have a significant impact on the health-related quality of life (HRQOL) of patients.[145-149] Both SWL and URS have been found to have significant impacts on kidney stone patients' quality of life.

Overall, patients with ureteral stones are satisfied with their treatment choice approximately 50% of the time and there is no difference in treatment satisfaction correlated to the selected modality (SWL vs. URS).[150-152] However, in one study specifically examining distal ureteric calculi, it was determined that more patients were satisfied with URS (n=113; 94.2%) compared to SWL (n=74; 80.4%) (p=0.002).[153]

Regarding HRQOL, the main HRQOL outcomes affected by SWL and URS are the physical functioning, social functioning, and pain domains on the 36-item Short Form Health Survey (SF-36).[154,155] A study comparing the HRQOL between patients who received SWL to those who received URS using the SF-36, found that patients who received URS scored worse than those who received SWL due in part to the higher analgesic requirements and longer hospital stay after URS compared to SWL, which was mainly attributed to the use of a ureteral stent.[156] Interestingly, the improved HRQOL for SWL over URS extended beyond the short-term and persisted at six months of followup, despite the higher SFR with URS. In contrast, a study compared the impact of URS vs. SWL on the HRQOL of patients with proximal ureteral stones and found that although there was no difference in change in HRQOL for patients with stones <10 mm, patients who underwent SWL for proximal ureteral stones >10 mm scored significantly lower on their SF-36.[157] Finally, a systematic review examined how ureteric calculi influence HRQOL and patient treatment preference.[158] A number of studies were reviewed, however, overall URS and SWL were both found to significantly impact SF-36 results similarly.

Recommendation: Overall, there is similar patient satisfaction between SWL and URS for the treatment of ureteric calculi, but SWL has been found to have slightly better HRQOL outcomes, due primarily to the avoidance of a ureteral stent *(level 2, moderate recommendation)*.

V. Special clinical considerations

Anticoagulation

Some studies have shown up to a 20- to 40-fold increased risk of peri-renal hematomas and hemorrhagic complications among patients with uncorrected coagulopathies undergoing SWL when compared with patients with a normal bleeding profile.[159-162] As such, in consultation with a hematologist or a cardiologist, bleeding coagulopathies need to be corrected and anticoagulation therapy appropriately withheld around the time of SWL.[163] Patients with an increased risk of thromboembolic disease should be managed by bridging therapy while oral anticoagulation is held.[164]

A retrospective study of 434 patients on acetylsalicylic acid (ASA) or low-molecular-weight heparin (LMWH) undergoing SWL for renal and proximal ureteric stones demonstrated that the continued use of ASA and a therapeutic (but not prophylactic) dose of LMWH were independent predictors of renal hematoma, as determined by ultrasound one day post-SWL.[165] A systematic review performed in 2014 found sparse and poor-quality evidence with respect to the safety of SWL while on antiplatelet or anticoagulant medications, but one of the authors' conclusions included careful consideration of SWL among patients on low-dose ASA.[166]

Recent advances in URS technology have made it possible for patients with coagulopathies to safely undergo URS and laser lithotripsy while anticoagulated.[160,167-170] However, this is associated with lower SFRs and increased risk of postoperative gross hematuria necessitating admission and bladder irrigation.[161,171] Therefore, risks and benefits of withholding anticoagulation or proceeding with URS while anticoagulated should be discussed with the patient and his/her cardiologist or hematologist.

In terms of using a UAS during URS for patients on anticoagulants, studies have demonstrated no increased risk of hemorrhagic complications.[116,169]

Recommendations: SWL and antegrade URS are contraindicated in patients with uncorrected coagulopathies. When the risk of holding antiplatelet or anticoagulants outweigh the benefits, proceeding with URS while a patient is anticoagulated is an acceptable option *(level 2, moderate recommendation)*.

Antegrade management of ureteral stones

Antegrade URS can be considered a treatment option in the following situations: 1) patients with a urinary diversion in whom SWL or retrograde access is not feasible; 2) in select cases with a large, impacted proximal ureteral stones; 3) when performed in conjunction with renal stone removal; 4) in select cases following failure of a retrograde URS attempt for a large, impacted proximal ureteral stone;[172] and 5) when the ureteral stone is in a transplant kidney.[173]

Dealing with stones in patients with urinary diversions represents a challenge to most urologists. The established anatomical changes in these patients necessitate accurate preoperative assessment by NCCT.[174] If SWL is not an option or the patient's stone doesn't respond to SWL, one of the most important factors to consider is whether retrograde access to the ureter is possible. If the ureter is accessible through a retrograde approach (e.g., through an ileal conduit), flexible retrograde URS may be a good option, as antegrade URS in these patients is associated with higher rates of postoperative fever or sepsis (8% vs. 0%, $p<0.05$) and higher rates of second-look nephroscopy (36% vs. 16%, $p<0.05$) compared to those with normal anatomy.[175]

For large (>15 mm), impacted, proximal ureteral stones, the SFR with antegrade URS ranges from 98.5–100%, with a low risk for complications.[172,176-180] However, as would be expected, the antegrade approach is associated with longer fluoroscopy time, longer procedural time, and longer hospital stay.[181]

Recommendations: Percutaneous antegrade URS should be considered in the treatment of stones in patients with urinary diversion and select large, impacted, proximal ureteral stones, especially when prior retrograde URS has failed *(level 4, strong recommendation)*.

Ureteral stones in children

Pediatric urolithiasis has become increasingly common in the last two decades, with the incidence increasing approximately 4–10% annually.[182,183]

Diagnostic imaging

Due to concerns regarding radiation exposure in children, US is used more commonly than in adults as the first-line diagnostic modality when renal colic is suspected.[184-186] However, similar to adults, there are sensitivity issues with US, in particular for mid-ureteral calculi.[187] The addition of conventional radiography (KUB X-ray) can improve diagnostic accuracy,[188,189] but as in adults, NCCT has the highest sensitivity and specificity.[185,186,190] The use of ultra-low-dose NCCT can mitigate radiation exposure to levels similar to KUB X-ray, while maintaining diagnostic performance.[191,192]

Management

The optimal management of ureteral stones in children is dependent on patient and stone factors, similar to adults, but the anatomic spectrum of pediatric patients, and the subsequent management, varies much more widely.[193] Unless there is an indication to intervene acutely, a trial of passage of at least two weeks is the first-line management in children with urolithiasis <5 mm.[105,185,193-196] If urinary drainage is urgently required, ureteral stent insertion is preferred in children due to decreased complications compared to percutaneous decompression. Evidence suggests MET in children may be effective and safe.[193,194,197]

There is a paucity of high-level evidence in the literature regarding the optimal management algorithm for pediatric patients requiring surgical intervention for ureteric stones.[193,198] In children with mid to distal urolithiasis, URS has been consistently shown to be superior to SWL and thus is recommended as first-line management.[105,185,199-201]

For children with proximal ureteral stones, the overall SFRs between SWL and URS have been shown to be similar,[198] so both SWL and URS may be considered first-line options. The usual considerations regarding the suitability of SWL must be considered. In children with large stone burdens, repeated procedures may be required or discussions involving more invasive options (percutaneous antegrade URS or open/laparoscopic/robotic procedures) may be undertaken.[105,185]

Retrograde access for children who have undergone a Cohen cross-trigonal ureteral re-implantation can be uniquely challenging but is not a contraindication for URS.[202]

Complications

The complication and re-treatment rates for pediatric SWL are similar to those of adults.[198,199] However, unlike the adult population, the complication rates for pediatric URS varies widely (3.7–20.5%).[188,198,203,204] In particular, overall reported rates of ureteral injury (2.1–2.8%), ureteric stricture (0.2–1.0%), and ureteral avulsion (0.4%) are higher among the pediatric population.[200,203] The complications associated with pediatric URS are more strongly linked with age/size of the child and equipment size.[203,205] To minimize ureteric complications, it is recommended that ureteroscopes <8 French be used on pediatric patients,[199,200,204,205] and that mini 4.5 French ureteroscopes be used for children <3 years old.[203]

Stenting

Data does not support routine pre-stenting prior to URS in children.[105] However, failed retrograde access is more common in children (30–70%) than adults.[196,206] In these situations, pre-stenting and repeat URS after passive dilation may be preferable to active dilation with catheters, balloon dilators, and sheaths due to risk of significant ureteric trauma. This is especially true in younger children.[188]

Postoperative stenting should be performed at the discretion of the attending physician, with similar indications as in adults.[185,205]

Followup

There are no clear differences between pediatric and adult followup post-surgical intervention for urolithiasis. In most series, postoperative ureteral stents are removed within 1–2 weeks under a second general anesthesia. Alternative options include magnetic and tethered stents.

Postoperatively, children should be followed with an US and KUB X-ray 4–6 weeks after the procedure.[200,205,207,208] After their first episode of urolithiasis, the overall recurrence rates in the pediatric population ranges from 19–50 % over a followup of 2–3 years.[195,209,210] However, there is currently no high-level evidence dictating a specific surveillance schedule. As such, it is recommended that this mirror that of the adult population.

Recommendation: Ultrasound is the first-line diagnostic modality used in children with suspected ureteral stones. This may be coupled with a KUB X-ray to increase accuracy. Low-dose NCCT may be used in certain situations *(level 3, strong recommendation)*. **A trial of passage with/without MET is recommended for children with smaller (<5 mm) stones** *(level 2, strong recommendation)*. **SWL is a safe and effective option for ureteral stones in children** *(level 2, strong recommendation)*. **If ureteral dilation is required, passive dilation is preferred** *(level 4, moderate recommendation)*. **It is recommended that ureteroscopes <8 French be used for URS in children** *(level 4, moderate recommendation)*.

Pregnancy

No level 1 evidence exists regarding the treatment of ureteral stones during pregnancy. Retrospective case series provide some guidance on how to manage this situation.

Diagnostic imaging

The first diagnostic test in suspected nephrolithiasis during pregnancy should be US (abdominal ± transvaginal) due to the lack of radiation. However, if US is non-diagnostic, magnetic resonance imaging (MRI) can be considered in the first trimester.[211,212] If available, a protocol involving magnetic resonance urography (MRU) with a T2-weighted half Fourier single-shot turbo spin-echo (HASTE) is preferred due to improved accuracy.[213] Ultra-low/low-dose NCCT may be considered as additional options in the second and third trimesters.[186,214,215]

Management

Most ureteral stones will pass spontaneously and the first option in management is conservative therapy, including hydration and analgesia.[216] NSAIDs should be avoided in pregnancy due to known fetal risks.[217] Data suggests MET with alpha-blockers is relatively safe in this patient population, however, efficacy is currently not well-established.[218,219] It should be noted that these medications are category B-rated and should be used with caution, as an off-label adjunct.[105]

Immediate causes for intervention are the same as those in non-pregnant situations, but also include induction of premature labor (contractions, fetal distress).[220] The immediate methods of intervention in these situations are NT or ureteral stent insertion. Although safe, the evidence for NT placement are comprised of small, low-level studies.[221-223] In pregnancy, ureteral stents and NTs are at risk for accelerated encrustation, thereby requiring changes every 4–6 weeks.[224,225]

Failing conservative management, URS using laser lithotripsy has been shown to be feasible and safe.[226] In fact, if ultrasound imaging is non-diagnostic and low-dose NCCT or MRI is unavailable, URS can also be used for both diagnostic and therapeutic purposes.[227,228] A number of studies have demonstrated that URS is a viable technique to treat stones in pregnancy.[227,229-233] Postoperative stenting following URS in this situation is recommended in an attempt to reduce postoperative complications.[227,234] With respect to safety of the pregnancy, traditional teaching was that URS should be undertaken during the second trimester,[220,235] but more recent literature suggests there is no evidence to support a "safest" trimester.[221]

With regards to intraoperative imaging, if URS or ureteral stent insertion is undertaken, then a lead apron or shield should be put between the X-ray fluoroscopy source and the fetus to shield it from radiation.[236] Alternatively, URS or ureteral stent insertion can be performed under US guidance alone, avoiding radiation exposure. Continuous fetal monitoring has been advocated during these interventions,[212,220] although may not always be necessary.

Pregnancy is a contraindication to SWL, and although there have been reports of the inadvertent treatment of pregnant patients with SWL with no adverse sequelae to the fetus,[237] it should be avoided. Similarly, antegrade URS should likely be delayed until after birth, as the procedure may require prolonged anesthesia and radiation exposure. However, some case series of safe PCNL during pregnancy have been published.[238]

Recommendation: First-line diagnostic testing for stones in pregnancy is US, but low-dose NCCT or MRI (without gadolinium in the first trimester) can also be used *(level 3, strong recommendation)*. **Obstructing ureteral stones in pregnancy can be managed conservatively in the absence of suspected or confirmed urinary infection** *(level 3, moderate recommendation)*. **In pregnant patients presenting with signs of sepsis, antibiotics and urinary decompression via a NT or ureteral stent are of primary importance; consultation with the obstetrics team is recommended. URS with laser lithotripsy is safe in pregnancy; however, SWL is contraindicated** *(level 2, strong recommendation)*.

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