

## Surgical Management of Kidney and Ureteral Stones: AUA Guideline (2026). Part III: Treatment of Patients With Kidney and/or Ureteral Stones and Future Directions

Margaret S. Pearle,<sup>1\*</sup> Brian R. Matlaga,<sup>2\*</sup> Jodi A. Antonelli,<sup>3</sup> Thomas Chi,<sup>4</sup> Ryan S. Hsi,<sup>5</sup> Sennett K. Kim,<sup>6</sup> Erin Kirkby,<sup>6</sup> Bodo Knudsen,<sup>7</sup> Kevin Koo,<sup>8</sup> Naim M. Maalouf,<sup>9</sup> Vernon M. Pais Jr,<sup>10</sup> Ann Paris,<sup>11</sup> Kristina L. Penniston,<sup>12</sup> Kymora B. Scotland,<sup>13</sup> Lesley H. Souter,<sup>14</sup> Necole Streeper,<sup>15</sup> Gregory Tasian,<sup>16</sup> Kyle D. Wood,<sup>4</sup> and Justin B. Ziemba<sup>17</sup>

<sup>1</sup>Department of Urology, University of Texas Southwestern Medical Center, Dallas, Texas

<sup>2</sup>Department of Urology, Johns Hopkins University School of Medicine, Baltimore, Maryland

<sup>3</sup>Department of Urology, Duke University, Durham, North Carolina

<sup>4</sup>Department of Urology, University of Alabama at Birmingham, Birmingham, Alabama

<sup>5</sup>Department of Urology, University of California, Irvine, Orange, California

<sup>6</sup>American Urological Association, Linthicum, Maryland

<sup>7</sup>Department of Urology, The Ohio State University, Columbus, Ohio

<sup>8</sup>Department of Urology, Mayo Clinic, Rochester, Minnesota

<sup>9</sup>Division of Endocrinology, Department of Internal Medicine, University of Texas Southwestern Medical Center, Dallas, Texas

<sup>10</sup>Section of Urology, Department of Surgery, Geisel School of Medicine at Dartmouth, Lebanon, New Hampshire

<sup>11</sup>Langhorne, Pennsylvania

<sup>12</sup>Department of Urology, University of Wisconsin School of Medicine and Public Health, Madison, Wisconsin

<sup>13</sup>Department of Urology, University of California, Los Angeles, Los Angeles, California

<sup>14</sup>Nomadic Evidence-Based Medicine Methodology, Smithville, Ontario, Canada

<sup>15</sup>Department of Urology, Medical College of Wisconsin, Milwaukee, Wisconsin

<sup>16</sup>Division of Urology, Department of Surgery, Children's Hospital of Philadelphia, Philadelphia, Pennsylvania

<sup>17</sup>Division of Urology, Department of Surgery, Perelman School of Medicine at the University of Pennsylvania and the Hospital of the University of Pennsylvania, Philadelphia, Pennsylvania

### Abbreviations and Acronyms

AC	=	anticoagulant
ACOG	=	American College of Obstetrics and Gynecology
ALARA	=	As Low As Reasonably Achievable
AP	=	antiplatelet
AUA	=	American Urological Association
CT	=	computed tomography
ED	=	emergency department
FANS-UAS	=	flexible and navigable suction ureteral access sheath
KUB	=	kidney, ureter, bladder radiography
Mini-PCNL	=	mini-percutaneous nephrolithotomy
MRI	=	magnetic resonance imaging
MUSIC	=	The Michigan Urological Surgery Improvement Collaborative
NSAID	=	nonsteroidal anti-inflammatory drug
PCNL	=	percutaneous nephrolithotomy
PPV	=	positive predictive value
RCS	=	retrospective cohort study
RCT	=	randomized controlled trial
RI	=	resistive index
SWL	=	shockwave lithotripsy
TFL	=	thulium fiber laser
UAS	=	ureteral access sheath
US	=	ultrasound
URS	=	ureteroscopy
UTI	=	urinary tract infection

**Purpose:** This Guideline covers the surgical treatment of patients with kidney and/or ureteral stones and is intended for clinicians evaluating and managing patients with these diseases. The summary presented herein represents Part III of the 3-part series dedicated to Surgical Management of Kidney and Ureteral Stones and Future Directions.

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

**Results:** The Panel addressed adult and pediatric patients with kidney and/or ureteral stones for whom surgical intervention may be indicated. Each statement herein addressed a particular patient scenario for which the choice of surgical intervention was reviewed and justified. In addition, the Panel reviewed and analyzed the utility of specific surgical techniques, technologies, or medications aimed at improving patient outcomes.

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

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

## GUIDELINE STATEMENTS

### Treatment of Patients With Kidney and/or Ureteral Stones

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

A meta-analysis of 21 randomized controlled trials (RCTs) demonstrated higher stone-free rates and reduced post-operative pain among those prescribed adjuvant alpha blockers after SWL compared to those not prescribed alpha blockers.<sup>1</sup> Of note, however, an RCT in pediatric patients undergoing SWL found no difference in stone-free rates in the alpha blocker group compared to the control group.<sup>2</sup>

Two additional RCTs demonstrated lower self-reported pain with alpha blocker use after SWL.<sup>3,4</sup>

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

While discontinuation of AC/AP therapy in the perioperative setting at the time of URS may improve intraoperative visualization, it is not clear that it affects outcomes. An international multi-center prospective URS registry showed a higher rate of bleeding complications in patients on perioperative AC/AP compared to those not on AC/AP therapy (1.1% vs 0.4%,  $P < .01$ ).<sup>5</sup> In addition, a study from the Michigan Urological Surgery Improvement Collaborative, representing multiple practice settings throughout the state of Michigan, demonstrated that while the continuation of both AP and AC increased the incidence of unplanned hospitalization, the difference was significant only in patients on AP therapy.<sup>6</sup> Finally, a single institution study specifically

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

The complete unabridged version of the guideline is available at [auanet.org/StonesSurgicalManagement](http://auanet.org/StonesSurgicalManagement).

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

**Funding/Support:** The Authors have no funding to disclose.

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

#### Author Contributions:

*Conception and design:* Pearle, Matlaga, Scotland, Tasian, Streeper, Penniston, Maalouf, Hsi, Pais, Chi, Wood, Knudsen, Ziemba, Antonelli, Koo, Kim, Kirkby, Souter.

*Critical revision of manuscript:* Pearle, Matlaga, Paris, Scotland, Tasian, Streeper, Penniston, Maalouf, Hsi, Pais, Chi, Wood, Knudsen, Ziemba, Antonelli, Koo, Kirkby, Kim, Souter.

*Data acquisition:* Souter.

*Data analysis and interpretation:* Pearle, Matlaga, Paris, Scotland, Tasian, Streeper, Penniston, Maalouf, Hsi, Pais, Chi, Wood, Knudsen, Ziemba, Antonelli, Koo, Kim, Souter.

*Drafting the manuscript:* Pearle, Matlaga, Scotland, Tasian, Streeper, Penniston, Maalouf, Hsi, Pais, Chi, Wood, Knudsen, Ziemba, Antonelli, Koo, Souter.

*Supervision:* Kim, Kirkby, Pearle, Matlaga, Tasian, Antonelli, Ziemba, Koo, Maalouf, Streeper, Hsi, Chi, Pais.

*Statistical analysis:* Wood, Scotland, Souter.

*Drafting and reviewing manuscript:* Knudsen.

**Corresponding Author:** Margaret S. Pearle, MD, PhD, Department of Urology, University of Texas Southwestern Medical Center, 2001 Inwood Road, West Campus Building 3, 4th Floor, Dallas, TX 75390-9110 ([margaret.pearle@utsouthwestern.edu](mailto:margaret.pearle@utsouthwestern.edu)).

\* Co-chair.

powered to examine the impact of bleeding-related complications during URS, found no difference in bleeding complications between patients who were or were not on AC/AP therapy.<sup>7</sup> Of note, pre-stenting in the setting of continuous AC/AP therapy did not appear to change composite bleeding risk for patients undergoing URS, although it did decrease intraoperative bleeding and need for unplanned reoperation.<sup>8</sup>

The Panel concluded that the data support the preferential use of URS for stone removal in patients who are unable to stop AC/AP therapy or in those with uncorrectable coagulopathies, presuming other factors do not preclude URS. However, consideration may be given to pre-stenting patients in this setting.

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

When comparing pre-stented patients to patients without pre-placed stents undergoing URS, there is not a clear association between stent placement and clinical outcome. Although some studies have demonstrated higher stone-free rates and lower ureteral injury rates, other outcomes, including emergency department (ED) visits, hospital readmissions, post-operative hydronephrosis, pain, and bleeding complications were analyzed sporadically in these studies and showed no demonstrable difference in outcomes between pre-stented and unstented patients undergoing URS.<sup>9,10</sup> Similarly, when a ureteral access sheath (UAS) was used during URS procedures, there were no differences in stone-free rates or incidence of ureteral injury between the pre-stented and not pre-stented patients.<sup>11</sup>

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

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

A review of the clinical evidence demonstrates no meaningful difference in stone-free rates following URS with or without the use of a UAS.<sup>12</sup> Concern for ureteral injury with use of a UAS has been unfounded, with several RCTs showing no difference in rates of ureteral injury between

patients undergoing URS with or without a UAS.<sup>12-14</sup> Furthermore, no differences in patient-reported pain have been demonstrated in patients undergoing URS with or without a UAS.<sup>12</sup> Finally, pre-placement of a ureteral stent has not been shown to improve outcomes of URS with a UAS with regard to stone-free rates, ureteral injury, bleeding complications, post-operative pain or ED visits.<sup>12-14</sup>

On the other hand, the risk of post-operative infectious complications may be reduced by use of a UAS. A 1-year global, prospective registry of 2239 patients undergoing flexible URS demonstrated no differences in stone-free rate, ureteral injury, or bleeding complications between those treated with or without a UAS, although infectious complications such as fever, UTI, and sepsis were lower among patients treated with a UAS.<sup>15</sup>

Passage of a UAS is not assured in all patients, and concern for ureteral injury has deterred some practitioners from routinely utilizing UAS. Two recent meta-analyses evaluated the benefit of pre-operative alpha blockers on URS with a UAS. Although 1 meta-analysis showed a reduction in the incidence of ureteral injuries and a higher likelihood of successful UAS insertion with the use of pre-operative alpha blockers, overall heterogeneity and discrepancies in the sensitivity analysis cast uncertainty on advantage of alpha-blockers with regard to UAS insertion.<sup>16</sup> The second meta-analysis found that pre-operative alpha blockers were associated with significantly lower risks of stone access failure, need for ureteral dilation, post-operative residual stones and complications, and a 6 minute shorter procedure time compared to the control group, all of which were significant.<sup>17</sup> The only adverse event that differed between groups was a higher risk of ejaculatory dysfunction in the alpha blocker group.<sup>17</sup>

Since these meta-analyses, another recent RCT demonstrated a higher rate of successful passage of a 12/14 Fr UAS in the alpha blocker group compared to the control group.<sup>18</sup> Consequently, clinicians may administer a short-course alpha blocker in advance of URS if use of a UAS is anticipated.

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

Two recent RCTs compared URS outcomes with the use of flexible and navigable suction UAS (FANS-UAS) vs standard UAS. One multi-center RCT showed higher 3-month CT stone-free rates, lower rates of post-operative fever, and greater improvement in quality of life scores in the FANS-UAS group compared with the traditional UAS

group.<sup>19</sup> A second RCT found significantly higher stone-free rates and lower visual analog pain scores in the FANS-UAS group compared to the standard UAS group.<sup>20</sup> Overall, among 8 studies in our systematic review (2 RCTS and 6 retrospective cohort studies [RCS])<sup>19-26</sup> comparing FANS-UAS with standard UAS, all but 1 study (RCS)<sup>24</sup> showed higher stone-free rates in the FANS-UAS group compared with standard UAS. Because the aggregate of these studies showed a serious risk of bias, the evidence grade for this recommendation is Grade C and the recommendation is Conditional. Whether incorporating suction and deflection into UAS tips the scales in favor of UAS-use remains to be seen.

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

Single-use flexible ureteroscopes represent an emerging technology for which uptake and use is multifactorial. A meta-analysis found that that single-use ureteroscopes are associated with higher stone-free rates and lower rates of post-operative UTIs compared to reusable flexible ureteroscopes.<sup>27</sup> However, there was substantial heterogeneity among the included trials with regard to the definition of stone free. Despite the advantages of single-use ureteroscopes, external factors such as practice environment may be the primary determinant of use of single-use ureteroscopes vs reusable ureteroscopes, which remain a viable option.

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

Although complications (eg, post-operative infection) and post-operative pain have been reported to occur at similar rates after URS using either a holmium:YAG laser or thulium fiber laser (TFL) laser,<sup>28,29</sup> stone-free rates have shown more variability among trials. Ulvik et al<sup>28</sup> reported higher stone-free rates for TFL compared to holmium:YAG laser lithotripsy for kidney stones, but comparable stone-free rates for ureteral stones in an RCT. A prospective cohort study and 2 other RCTs showed no significant difference in stone-free rates for URS using the 2 lasers.<sup>29,30</sup> However, 1 trial showed a higher rate of ureteral mucosal injury with TFL compared to holmium:YAG laser lithotripsy.

For patients with ureteral stones, clinicians should consider the uncertain benefits and the potential for higher risk with TFL lithotripsy in the ureter.

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

A guiding principle when utilizing URS to treat stones in the kidney and/or ureter is to use the lowest power settings necessary to ablate the stone, while minimizing the risk of injury. Unnecessary increases in frequency made possible by high-power lasers can increase the risk of injury due to higher delivered power that increases intra-renal temperature and laser pulses that hit the surrounding tissue rather than the stone. Although this principle applies equally to stones in the kidneys and ureters, particular care should be taken when performing URS with laser lithotripsy for ureteral stones, as the default power settings provided by the manufacturer have been associated with ureteral strictures. In particular, when treating ureteral stones, it is advisable to use the minimum energy required to treat the stone (eg, <10 W), particularly when using low irrigation flow rates.

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

“Dusting” is a strategy to lase stones into fine particles or “dust,” while fragmentation and basketing implies fracturing stones into pieces that can be individually withdrawn. A meta-analysis comparing the 2 strategies found a higher stone-free rate with basketing than dusting.<sup>31</sup> While operative time was 11.6 minutes shorter in the dusting group compared to the basketing group, retreatment rate favored basketing. A more recent RCT of 60 patients undergoing URS for proximal ureteral stones found no difference in stone-free rates between the 2 groups.<sup>32</sup> The Panel acknowledges that the recent introduction of active suction during URS and the widespread use of TFL, neither of which technologies were represented in most of the analyzed studies, will necessitate further evaluation to better define these technologies during URS and to assess their impact on the selection of laser strategy during URS.

In pediatric patients, basketing and dusting strategies for URS have been shown to yield comparable outcomes. Stone clearance for semi-rigid URS with laser lithotripsy for pediatric patients with ureteral stones using either fragmentation/basketing or dusting is high (>96%) based on ultrasound (US) and KUB, with no discernable difference in outcomes between the 2 techniques.<sup>33</sup>

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

Uncomplicated URS is variably defined as URS performed in patients with 2 functioning, anatomically normal kidneys for kidney and/or unimpacted ureteral stones, for which there is no suspicion of residual ureteral fragments and no signs of injury or significant edema. Among 5 RCTs comparing outcomes after URS in patients who were or were not stented after the procedure, 4 showed no difference in post-operative ED visits between stented and unstented patients,<sup>34-37</sup> although 1 study reported a higher rate of ED visits in the stented group.<sup>38</sup> Furthermore, although most trials found no difference in pain intensity between patients with or without stents after URS,<sup>35,39</sup> 2 RCTs noted less patient-reported pain in unstented compared to stented patients after URS.<sup>40,41</sup> Overall, omitting stent placement after uncomplicated URS does not appear to increase post-operative morbidity.

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

Surgical collection of stone material or collection of stone fragments after SWL may provide the only opportunity to determine stone composition. In some cases, knowledge of stone composition can predict the underlying metabolic abnormalities contributing to stone formation, such as for uric acid, struvite, and cystine stones.<sup>42</sup> Furthermore, it can impact future decisions regarding surgical stone management because of known limitations of surgical technologies with some stone types (ie, cystine stones are relatively SWL-resistant).

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

A large retrospective cohort study demonstrated that patients *not* prescribed post-operative opioids had significantly lower rates of unplanned ED visits and readmission rates compared to those prescribed opioids after URS.<sup>43</sup> In contrast, a smaller prospective cohort study demonstrated no difference in ED visits among those prescribed only opioids vs those prescribed NSAIDs.<sup>44</sup>

Opioids have not demonstrated superior pain control after URS or percutaneous nephrolithotomy

(PCNL) compared to NSAIDs. In a prospective cohort study of patients undergoing URS, those not prescribed opioids had no greater pain in the recovery room, after discharge, or on the evening after surgery compared to those prescribed opioids.<sup>44</sup> Likewise, a retrospective cohort study of patients who underwent PCNL showed no difference in unplanned pain-related ED visits, office phone calls, or office visits in patients prescribed ketorolac compared with those prescribed opioids.<sup>45</sup> Finally, an RCT of patients undergoing either PCNL or URS showed comparable satisfaction with pain relief between those prescribed adjuvant opioids and those prescribed ketorolac, although self-reported average pain intensity was higher in those prescribed opioids compared to those who received ketorolac.<sup>46</sup> Based on these data, the Panel recommends non-opioid-based multimodal pain regimens as first-line therapy for patients undergoing surgical stone procedures.

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

In the post-treatment setting, use and timing of a specific imaging modality should be individualized based on patient characteristics (eg, age, body habitus), risk factors for stone recurrence, and treatment goals. If residual fragments are identified on follow-up imaging after surgery, the patient can be counseled on the risk of future stone events and the benefit of secondary procedures to achieve a stone-free state vs observation with active surveillance. Although the optimal timing of initial follow-up imaging has not been established, 4 to 12 weeks after surgical intervention is a common and reasonable practice. Although among imaging modalities CT has the highest sensitivity and specificity for the detection of residual fragments after surgery, it subjects patients to ionizing radiation,<sup>47</sup> and therefore KUB and US are typically used to assess stone clearance and hydronephrosis. However, low dose and ultra-low dose CT protocols can be utilized, consistent with the As Low As Reasonably Achievable (ALARA) principle. A multi-center retrospective analysis of post-URS imaging within 3 months showed that CT had the highest frequency of detecting stone fragments associated with stone events and reintervention compared to KUB or combination KUB/US.<sup>48</sup> Of note, only US and CT, but not KUB, can determine the presence of post-operative hydronephrosis. While rare, new or worsening hydronephrosis after treatment can lead to the permanent loss of renal function if the

obstruction is prolonged, and therefore assessment of post-operative renal drainage is essential.

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

The decision to manage residual fragments with observation vs active intervention depends on the balance between the risk of an additional surgical procedure and the benefit of preventing pain, obstruction, infection, or continued stone growth that risks the need for urgent intervention. Although any residual fragment may ultimately require intervention, several studies have shown that the risk of requiring intervention is greater for larger vs smaller residual fragments. RCS evaluating the outcome of residual fragments after surgical stone procedures have shown that residual fragments > 4 mm in size are associated with higher rates of unplanned secondary procedures than residual fragments ≤ 4 mm in size.<sup>49</sup> In addition, a meta-analysis of 18 studies with over 2000 patients with residual fragments following SWL, URS, or PCNL reported that patients with > 4 mm residual fragments had 50% greater odds of requiring an unplanned secondary procedure compared to patients with smaller fragments (Odds Ratio: 1.50; 95% CI: 0.70-2.30).<sup>50</sup>

Residual fragments after PCNL represent a unique consideration due to the ability to perform a secondary procedure through an existing tract with flexible nephroscopy, which may be performed during the same admission. As recommended in Part II of the summary, for patients undergoing PCNL, clinicians may obtain a CT in the immediate/early post-operative period to assess stone-free status and determine the need for a secondary procedure. Clinicians should offer URS or flexible nephroscopy to retrieve residual fragments after PCNL, even if the decision is ultimately made to defer. Although traditionally, second look flexible nephroscopy was utilized to retrieve residual stones, secondary URS, particularly if no nephrostomy tube is left after PCNL, is an alternative modality. URS was found in both an RCT<sup>51</sup> and retrospective cohort study<sup>52</sup> to yield higher stone-free rates compared to SWL for removal of post-PCNL residual fragments.

The Panel acknowledges that in recent years tubeless PCNL has become more common, and recent studies often do not include second look flexible nephroscopy. However prior studies supported treating residual fragments > 2 mm with flexible nephroscopy to prevent future stone events.<sup>53</sup> Additional

studies found significantly higher rates of stone-related events for residual fragments > 4 mm after PCNL and higher rates of fragment growth or obstruction for residual fragments > 3 mm after PCNL.<sup>49,54</sup> The high incidence of stone-related events should encourage clinicians to at least offer a secondary procedure to treat residual fragments after PCNL.

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

### **Treatment of Pregnant Patients With Kidney or Ureteral Stones**

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

Because US is noninvasive and has no associated ionizing radiation, it is the recommended first-line imaging modality in pregnant women with suspected obstructing stones during pregnancy.<sup>55</sup> If diagnostic uncertainty persists after abdominal US imaging, transvaginal US has been demonstrated to be a useful adjunct in diagnosis of distal ureteral stones, outperforming transabdominal US and detecting 94% of distal ureteral stones.<sup>56</sup> Additionally, Doppler US and calculation of renal resistive index may improve utility of US for diagnosing stones during pregnancy. Although there is currently no data in pregnant patients, non-visualization of the ipsilateral ureteral jet on US of the bladder may suggest obstruction.<sup>57</sup> However, limitations of US remain well recognized, particularly in light of the occurrence of physiologic hydronephrosis of pregnancy which may confound accurate diagnosis. Therefore, additional imaging modalities may also be necessary when diagnostic uncertainty persists.

Like US, non-contrast MRI also avoids exposure to ionizing radiation and can be used during any trimester. However, stones are not directly visualized on MRI, and therefore interpretation must rely on secondary findings associated with obstruction. As such, MRI has a reported 80% positive predictive value for stones.<sup>58</sup>

By far, the most accurate imaging modality for the diagnosis of ureteral stones in pregnancy is non-contrast CT. Teratogenic effects of fetal radiation

exposure are highest between the 2nd and 20th weeks of gestation; nevertheless, typical stone protocol CT imaging is performed at doses below teratogenic thresholds of 5 rad (50 milligray).<sup>59</sup> When uncertainty persists after US imaging and a prompt diagnosis provides maternal benefit outweighing fetal risks, CT has been advocated and demonstrates diagnostic utility.<sup>59,60</sup> Low dose protocols can be utilized.

When employing any imaging study during pregnancy, it is most prudent to involve the obstetric team. If ionizing radiation is to be utilized, the clinician should consider further consultation with radiology and/or a medical physicist.<sup>59</sup> These consultants can best inform shared decision-making with the patient.

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

Urolithiasis during pregnancy presents a myriad of challenges, including those arising from the maternal physiologic response to pregnancy, the presence of the developing fetus in utero, and potential fetal implications of exposure to medications, radiation, and anesthetics. These concerns demand a multidisciplinary approach. Obstetricians as well as radiologists, radiation physicists, anesthesiologists, and pharmacists may offer important insights into maternal and fetal risks of management. Additionally, the American College of Obstetrics and Gynecology (ACOG) issued a committee statement that when considering surgery, an obstetrician should be notified and readily available.<sup>61</sup>

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

Successful trial of passage for ureteral stones during pregnancy has been reported, although in retrospective data, both rate of passage and time to passage varied. Utilizing strict criteria, passage rates have been reported to be as low as 48%.<sup>62</sup> More recent studies have reported stone passage in 40% to 60% of women, with mean time to passage between 17 and 35 days.<sup>63</sup> Patients should be counseled that if observation is elected, delayed intervention may be required. Intractable symptoms should prompt consideration of intervention.

The utility of tamsulosin in promoting spontaneous stone passage in pregnant women with ureteral stones has been evaluated in RCS.<sup>63,64</sup> While 2 studies concluded that tamsulosin did not appear to be associated with adverse effects for either mother or unborn child, neither demonstrated significantly

improved rates of passage in the tamsulosin cohort compared to the observation cohort.

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

For a pregnant woman with a ureteral stone who declines or experiences an unsuccessful trial of passage, the clinician may offer URS for planned definitive treatment. The safety of URS during pregnancy has been demonstrated, with published reports showing no difference in endoscopic complications compared with URS in the nonpregnant patient.<sup>65</sup> A 4.3% risk of obstetric complications including preterm labor has been reported, consistent with risk of obstetric complications associated with non-urologic surgery during pregnancy.<sup>66</sup> The ACOG committee statement recommends notification of and coordination with an obstetrician and delineates perioperative and intraoperative fetal monitoring recommendations.<sup>61</sup>

Nonobstetric surgery during any trimester is associated with potential adverse birth outcomes. ACOG recommends that while elective surgery should be postponed until after delivery, medically necessary surgery during pregnancy should not be denied or delayed, regardless of trimester.<sup>61</sup> In the opinion of the Panel, the preferred timing for intervention is during the second trimester, after the period of fetal viability has been reached.

Although both stent and nephrostomy drainage may be considered viable alternatives to URS, growing retrospective evidence suggests advantages of stent over nephrostomy management. Compared to a nephrostomy tube, ureteral stenting was associated with lower risk for UTI, inpatient hospitalization, and ED visits.<sup>67</sup> Due to accelerated encrustation during pregnancy, both nephrostomy tubes and ureteral stents require more frequent stent exchange, typically every 4 to 6 weeks.

## FUTURE DIRECTIONS

The intensive work that went into developing this Guideline has identified much that has been accomplished in advancing our understanding of the treatment of patients with kidney and ureteral stones but has also identified gaps in knowledge. Given the prevalence of this condition, efforts to fill these gaps will result in a broader understanding of how to treat patients optimally and will meaningfully benefit urologic

practice. As has been noted in many AUA Guideline documents, there is a paucity of high-quality RCTs in the urologic field that compare outcomes for surgical interventions. In addition to this Guideline serving as a call for future studies of high-quality design, there is also a need to ensure that the reporting of outcomes in these studies is standardized and reproducible. In many cases, this Guideline was challenged by heterogeneous reporting of clinical outcomes.

In this Guideline, we now see the introduction of mini-PCNL and suction technologies. However, in many cases these technologies are still sensitive to the patient's baseline stone burden. In other cases, such as utilizing high frequency lasers for a "dusting" approach to stone treatment, the outcomes appear to be inferior to the prior technique of basket extraction. As always, future efforts should continue to be devoted to improving the efficiency of stone removal through less invasive platforms as this will continue to further benefit patients. During the drafting of this Guideline, it has been apparent that novel therapies have recently arrived or are going to be arriving in the clinical domain. Among these therapies are suction-based retrograde approaches, ultrasonic propulsion burst wave lithotripsy, robotic

platforms, hybrid lasers, and the ability to monitor collecting system temperature and pressure. Importantly, as these novel technologies and techniques are introduced, they should be rigorously and critically assessed in clinical investigations that employ clearly described, high quality imaging, and adhere to standardized definitions of treatment outcomes.

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

## REFERENCES

- Brain E, Geraghty RM, Tzelvels L, et al. Outcomes of alpha-blockers as medical expulsive therapy following shockwave lithotripsy: a systematic review and meta-analysis. *BJU Int*. 2023;131(4):424-433. doi:10.1111/bju.15901
- Shahat A, Elderwy A, Safwat AS, et al. Is tamsulosin effective after shock wave lithotripsy for pediatric renal stones? A randomized, controlled study. *J Urol*. 2016;195(4 pt 2):1284-1288. doi:10.1016/j.juro.2015.11.021
- Shaikh AA, Patujo YH, Shaikh AB, et al. Comparison of efficacy with and without tamsulosin as medical adjuvant therapy after extracorporeal shockwave lithotripsy in renal stone. *Rawal Med J*. 2018;43:471.
- Basri C, Sinanoglu O, Mahmure U. The effect of tamsulosin on pain and clearance according to ureteral stone location after shock wave lithotripsy. *Curr Ther Res Clin Exp*. 2013;74:33-35. doi:10.1016/j.curtheres.2012.12.003
- Daels FP, Gaizauskas A, Rioja J, et al. Age-related prevalence of diabetes mellitus, cardiovascular disease and anticoagulation therapy use in a urolithiasis population and their effect on outcomes: the clinical research office of the endourological society ureteroscopy global study. *World J Urol*. 2015;33(6):859-864. doi:10.1007/s00345-014-1382-6
- Hiller SC, Qi J, Leavitt D, et al. Ureteroscopy in patients taking anticoagulant or antiplatelet therapy: practice patterns and outcomes in a surgical collaborative. *J Urol*. 2021;205(3):833-840. doi:10.1097/JU.0000000000001416
- Westerman ME, Scales JA, Sharma V, Gearman DJ, Ingimarsson JP, Krambeck AE. The effect of anticoagulation on bleeding-related complications following ureteroscopy. *Urology*. 2017;100:45-52. doi:10.1016/j.urology.2016.09.034
- Berger JH, DiPina T, Alshara L, et al. The effect of pre-stenting on bleeding-related complications following ureteroscopy in patients on anticoagulation or antiplatelet therapy. *J Endourol*. 2023;37(11):1174-1178. doi:10.1089/end.2023.0300
- Netsch C, Knipper S, Bach T, Herrmann TRW, Gross AJ. Impact of preoperative ureteral stenting on stone-free rates of ureteroscopy for nephroureterolithiasis: a matched-paired analysis of 286 patients. *Urology*. 2012;80(6):1214-1219. doi:10.1016/j.urology.2012.06.064
- Rubenstein RA, Zhao LC, Loeb S, Shore DM, Nadler RB. Prestenting improves ureteroscopic stone-free rates. *J Endourol*. 2007;21(11):1277-1280. doi:10.1089/end.2007.9888
- Sung LH, Cho DY. The role of preoperative ureteral stenting in retrograde intrarenal surgery in renal stone patients: a propensity score-matched study. *Translational Androl Urol*. 2020;9(2):276-283. doi:10.21037/tau.2020.03.09
- Singh S, Parmar K, Devana SK, Singh SK. Effect of ureteric access sheath on outcomes of retrograde intrarenal surgery for renal stone disease: a randomized controlled trial. *World J Urol*. 2023;41(5):1401-1406. doi:10.1007/s00345-023-04369-0
- Abdelfatah ZMM, Farouk SA, El-Mageed Salem TA, et al. Impact of ureteric access sheath use during flexible ureteroscopy: a comparative study on efficacy and safety. *Actas Urol Esp*. 2023;12:12.
- Bozzini G, Bevilacqua L, Besana U, et al. Ureteral access sheath-related injuries vs. post-operative infections. Is sheath insertion always needed? A prospective randomized study to understand the lights and shadows of this practice. *Actas Urol Esp*. 2021;45(9):576-581. doi:10.1016/j.acuroe.2020.11.010
- Traxer O, Wendt-Nordahl G, Sodha H, et al. Differences in renal stone treatment and outcomes for patients treated either with or without the support of a ureteral access sheath: the clinical research office of the Endourological Society Ureteroscopy Global Study. *World J Urol*. 2015;33(12):2137-2144. doi:10.1007/s00345-015-1582-8

16. Victor DR, Oliveira RAP, Melão B, Coelho HGB, Barros Júnior TDP. Preoperative  $\alpha$ 1-blockers impact on outcomes of patients undergoing ureteroscopy with ureteral access sheaths: a systematic review and meta-analysis. *J Endourol.* 2024;38(9):936-947. doi:10.1089/end.2024.0060
17. Bhojani N, Chew BH, Bhattacharyya S, Krambeck AE, Ghani KR, Miller LE. Effect of preoperative alpha-blockers on ureteroscopy outcomes: a meta-analysis of randomised trials. *BJUI Compass.* 2024;5(7):613-620. doi:10.1002/bco2.358
18. Nam KH, Suh J, Shin JH, Chae HK, Park HK. Effect of perioperative tamsulosin on successful ureteral access sheath placement and stent-related symptom relief: a double-blinded, randomized, placebo-controlled study. *Invest Clin Urol.* 2024;65(4):342-350. doi:10.4111/icu.20240005
19. Zhu W, Liu S, Cao J, et al. Tip bendable suction ureteral access sheath versus traditional sheath in retrograde intrarenal stone surgery: an international multicentre, randomized, parallel group, superiority study. *EclinicalMedicine.* 2024;74:102724. doi:10.1016/j.eclinm.2024.102724
20. Cacciatore L, Minore A, Bonanno L, et al. Is flexible navigable suction ureteral access sheath (fans) safer and more efficient than conventional sheaths? Italian multicentric experience. *World J Urol.* 2025;43(1):153. doi:10.1007/s00345-025-05520-9
21. Xu M, Jin L, Yang D, Xue B, Sun C, Tao W. Comparison of flexible vacuum-assisted ureteral access sheath versus conventional sheath combined with single-use flexible ureteroscope in the treatment of renal calculi. *Urolithiasis.* 2025;53(1):37. doi:10.1007/s00240-025-01699-z
22. Ong CSH, Somani BK, Chew BH, et al. Multicentre study comparing outcomes of RIRS using traditional suction ureteral access sheath (SUAS) and flexible and navigable suction uas (FANS). *J Clin Urol.* 2024;18(6):447-456. doi:10.1177/20514158241272717
23. Rico L, Diaz-Zorita V, Blas L, Ramos LB, Sabeh P, Contreras P. Is the ablation stone efficacy and efficiency better with a flexible and navigable suction ureteric access sheath?. *World J Urol.* 2025;43(1):219. doi:10.1007/s00345-025-05610-8
24. Hu H, Qin M, Yang L, et al. Analysis of the effectiveness and safety of 7.5 Fr ultra-thin flexible ureteroscope combined with a tip-flexible suctioning ureteral access sheath for the treatment of kidney stones. *Int Urol Nephrol.* 2025;57(3):817-823. doi:10.1007/s11255-024-04269-1
25. Chen H, Xiao J, Ge J, Liu T. Clinical efficacy analysis of tip-flexible suctioning ureteral access sheath combined with disposable flexible ureteroscope to treat 2-4 cm renal stones. *Int Urol Nephrol.* 2024;56(10):3193-3199. doi:10.1007/s11255-024-04072-y
26. Ying Z, Dong H, Li C, et al. Efficacy analysis of tip-flexible suction access sheath during flexible ureteroscopic lithotripsy for unilateral upper urinary tract calculi. *World J Urol.* 2024;42(1):626. doi:10.1007/s00345-024-05325-2
27. Zhang F, Xu J, Liang H. Single-use flexible ureteroscope provides an alternative treatment for upper urinary calculi: a systematic review and meta-analysis. *Medicine.* 2023;102(36):e34829. doi:10.1097/MD.00000000000034829
28. Ulvik Ø, Aesøy MS, Juliebø-Jones P, Gjengstø P, Beisland C. Thulium fibre laser versus holmium:YAG for ureteroscopic lithotripsy: outcomes from a prospective randomised clinical trial. *Eur Urol.* 2022;82(1):73-79. doi:10.1016/j.eururo.2022.02.027
29. Chandramohan V, Swamy PMS, Ramakrishna P, et al. Ureteroscopic lithotripsy by thulium fiber laser versus holmium laser: a single-center prospective randomized study. *Urol Ann.* 2023;15(3):285-288. doi:10.4103/ua.ua\_115\_22
30. Gauhar V, Traxer O, Fong KY, et al. Comparing thulium fiber versus high-power holmium laser lithotripsy combined with the flexible and navigable suction access sheath in flexible ureteroscopy for kidney stone disease: a propensity score matched analysis by the global fans collaborative group. *J Endourol.* 2025;39(1):42-49. doi:10.1089/end.2024.0653
31. Wen Z, Wang L, Liu Y, et al. A systematic review and meta-analysis of outcomes between dusting and fragmentation in retrograde intrarenal surgery. *BMC Urol.* 2023;23(1):113. doi:10.1186/s12894-023-01283-w
32. Albala DM, Assimos DG, Clayman RV, et al. Lower pole I: a prospective randomized trial of extracorporeal shock wave lithotripsy and percutaneous nephrostolithotomy for lower pole nephrolithiasis-initial results. *J Urol.* 2001;166(6):2072-2080. doi:10.1016/s0022-5347(05)65508-5
33. Fahmy A, Youssif M, Rhashad H, Orabi S, Mokless I. Extractable fragment versus dusting during ureteroscopic laser lithotripsy in children: prospective randomized study. *J Pediatr Urol.* 2016;12(4):254.e1-4. doi:10.1016/j.jpuro.2016.04.037
34. Ahmad N, Farhan M, Rehman IU, Rashidullah M, Ullah S, Ullah M. Study to determine the requirement of ureteral stent after uncomplicated ureteroscopy for ureteric stones. *Pakistan J Med Health Sci.* 2022;16(1):1102-1104. doi:10.53350/pjmhs221611102
35. Cevik I, Dillioglugil O, Akdas A, Siegel Y. Is stent placement necessary after uncomplicated ureteroscopy for removal of impacted ureteral stones?. *J Endourol.* 2010;24(8):1263-1267. doi:10.1089/end.2009.0153
36. Chen YT, Chen J, Wong WY, Yang SSD, Hsieh CH, Wang CC. Is ureteral stenting necessary after uncomplicated ureteroscopic lithotripsy? A prospective, randomized controlled trial. *J Urol.* 2002;167(5):1977-1980. doi:10.1016/s0022-5347(05)65066-5
37. Zaki MR, Salman A, Chaudhary AH, et al. Is DJ stenting still needed after uncomplicated ureteroscopic lithotripsy? A randomized controlled trial. *Pakistan J Med Health Sci.* 2011;5:121.
38. Allam CL, Aden JK, Reed AM. The role of routine ureteral stenting following uncomplicated ureteroscopic treatment for upper ureteral and renal stones: a randomized control trial. *J Endourol.* 2023;37(3):257-263. doi:10.1089/end.2022.0386
39. Ibrahim HM, Al-Kandari AM, Shaaban HS, Elshebini YH, Shokeir AA. Role of ureteral stenting after uncomplicated ureteroscopy for distal ureteral stones: a randomized, controlled trial. *J Urol.* 2008;180(3):961-965. doi:10.1016/j.juro.2008.05.030
40. Shao Y, Zhuo J, Sun XW, Wen W, Liu HT, Xia SJ. Nonstented versus routine stented ureteroscopic holmium laser lithotripsy: a prospective randomized trial. *Urol Res.* 2008;36(5):259-263. doi:10.1007/s00240-008-0153-5
41. El Harrech Y, Abakka N, El Anzaoui J, Ghoundale O, Touiti D. Ureteral stenting after uncomplicated ureteroscopy for distal ureteral stones: a randomized, controlled trial. *Minim Invasive Surg.* 2014;2014:892890. doi:10.1155/2014/892890
42. Pak CY, Poindexter JR, Adams-Huet B, Pearle MS. Predictive value of kidney stone composition in the detection of metabolic abnormalities. *Am J Med.* 2003;115(1):26-32. doi:10.1016/s0002-9343(03)00201-8
43. Hawken SR, Hiller SC, Daignault-Newton S, et al; Michigan Urological Surgery Improvement Collaborative. Opioid-free discharge is not associated with increased unplanned healthcare encounters after ureteroscopy: results from a Statewide Quality Improvement Collaborative. *Urology.* 2021;158:57-65. doi:10.1016/j.urology.2021.07.037
44. Bevil MD, Schutte ME, Flynn KJ, Said MA, Ten Eyck P, Tracy CR. Prospective comparison of opioid vs nonopioid pain regimen after ureteroscopy. *J Endourol.* 2022;36(6):734-739. doi:10.1089/end.2021.0719
45. Khargi R, Yaghoubian AJ, Blake RM, et al. Opioid-free percutaneous nephrolithotomy: an initial experience. *World J Urol.* 2023;41(11):3113-3119. doi:10.1007/s00345-023-04600-y
46. Demasi M, Segall M, Mengotto A, et al. Optimizing pain management following kidney stone surgery: can we avoid narcotics?. *World J Urol.* 2022;40(12):3061-3066. doi:10.1007/s00345-022-04214-w
47. Danilovic A, Cavalanti A, Rocha BA, et al. Assessment of residual stone fragments after retrograde intrarenal surgery. *J Endourol.* 2018;32(12):1108-1113. doi:10.1089/end.2018.0529
48. Gauhar V, Castellani D, Chew BH, et al. Does unenhanced computerized tomography as

- imaging standard post-retrograde intrarenal surgery paradoxically reduce stone-free rate and increase additional treatment for residual fragments? Outcomes from 5395 patients in the flexor study by the tower group. *Ther Adv Urol.* 2023;15:17562872231198629. doi:10.1177/17562872231198629
49. Wong VKF, Que J, Kong EK, et al. The fate of residual fragments after percutaneous nephrolithotomy: results from the endourologic disease group for excellence research consortium. *J Endourol.* 2023;37(6):617-622. doi:10.1089/end.2022.0561
  50. Brain E, Geraghty RM, Lovegrove CE, Yang B, Somani BK. Natural history of post-treatment kidney stone fragments: a systematic review and meta-analysis. *J Urol.* 2021;206(3):526-538. doi:10.1097/JU.0000000000001836
  51. Xu G, Wen J, Li Z, et al. A comparative study to analyze the efficacy and safety of flexible ureteroscopy combined with holmium laser lithotripsy for residual calculi after percutaneous nephrolithotripsy. *Int J Clin Exp Med.* 2015;8(3):4501-4507.
  52. Danilovic A, Torricelli FCM, Marchini GS, et al. Residual stone fragments after percutaneous nephrolithotomy: shockwave lithotripsy vs retrograde intrarenal surgery. *J Endourol.* 2021;35(5):609-614. doi:10.1089/end.2020.0868
  53. Raman JD, Bagrodia A, Gupta A, et al. Natural history of residual fragments following percutaneous nephrostolithotomy. *J Urol.* 2009;181(3):1163-1168. doi:10.1016/j.juro.2008.10.162
  54. Osman Y, Harraz AM, El-Nahas AR, et al. Clinically insignificant residual fragments: an acceptable term in the computed tomography era?. *Urology.* 2013;81(4):723-726. doi:10.1016/j.urology.2013.01.011
  55. Patel SJ, Reede DL, Katz DS, Subramaniam R, Amorosa JK. Imaging the pregnant patient for nonobstetric conditions: algorithms and radiation dose considerations. *Radiographics.* 2007;27(6):1705-1722. doi:10.1148/rg.276075002
  56. Bold MS, Boyum JH, Potretzke AM, et al. Detection of distal ureteral stones in pregnancy using transvaginal ultrasound. *J Ultrasound.* 2021;24(4):397-402. doi:10.1007/s40477-020-00504-4
  57. Shokeir AA, Mahran MR, Abdulmaaboud M. Renal colic in pregnant women: role of renal resistive index. *Urology.* 2000;55(3):344-347. doi:10.1016/s0090-4295(99)00475-6
  58. White WM, Johnson EB, Zite NB, et al. Predictive value of current imaging modalities for the detection of urolithiasis during pregnancy: a multicenter, longitudinal study. *J Urol.* 2013;189(3):931-934. doi:10.1016/j.juro.2012.09.076
  59. Chen MM, Coakley FV, Kaimal A, Laros RK Jr. Guidelines for computed tomography and magnetic resonance imaging use during pregnancy and lactation. *Obstet Gynecol.* 2008;112(2 pt 1):333-340. doi:10.1097/AOG.0b013e318180a505
  60. White WM, Zite NB, Gash J, Waters WB, Thompson W, Klein FA. Low-dose computed tomography for the evaluation of flank pain in the pregnant population. *J Endourol.* 2007;21(11):1255-1260. doi:10.1089/end.2007.0017
  61. ACOG Committee Opinion No. 775: nonobstetric surgery during pregnancy. *Obstet Gynecol.* 2019;133:e285.
  62. Burgess KL, Gettman MT, Rangel LJ, Krambeck AE. Diagnosis of urolithiasis and rate of spontaneous passage during pregnancy. *J Urol.* 2011;186(6):2280-2284. doi:10.1016/j.juro.2011.07.103
  63. Theriault B, Morin F, Cloutier J. Safety and efficacy of tamsulosin as medical expulsive therapy in pregnancy. *World J Urol.* 2020;38(9):2301-2306. doi:10.1007/s00345-019-03022-z
  64. Bailey G, Vaughan L, Rose C, Krambeck A. Perinatal outcomes with tamsulosin therapy for symptomatic urolithiasis. *J Urol.* 2016;195(1):99-103. doi:10.1016/j.juro.2015.06.097
  65. Semins MJ, Trock BJ, Matlaga BR. The safety of ureteroscopy during pregnancy: a systematic review and meta-analysis. *J Urol.* 2009;181(1):139-143. doi:10.1016/j.juro.2008.09.029
  66. Johnson EB, Krambeck AE, White WM, et al. Obstetric complications of ureteroscopy during pregnancy. *J Urol.* 2012;188(1):151-154. doi:10.1016/j.juro.2012.02.2566
  67. Mason MM, Nackeeran S, Lokeshwar S, et al. A comparison of adverse pregnancy events between ureteral stents and percutaneous nephrostomy tubes in the treatment of nephrolithiasis during pregnancy: a propensity score-matched analysis of a large multi-institutional research network. *World J Urol.* 2023;41(7):1721-1726. doi:10.1007/s00345-022-04111-2