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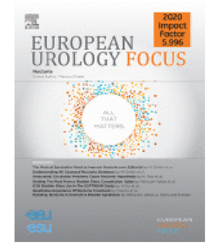

Guidelines

Best Practice in Interventional Management of Urolithiasis: An Update from the European Association of Urology Guidelines Panel for Urolithiasis 2022

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Abstract

Purpose: The European Association of Urology (EAU) has updated its guidelines on clinical best practice in urolithiasis for 2021. We therefore aimed to present a summary of best clinical practice in surgical intervention for patients with upper tract urolithiasis.
Materials and methods: The panel performed a comprehensive literature review of novel data up to May 2021. The guidelines were updated and a strength rating was given for each recommendation, graded using the modified Grading of Recommendations, Assessment, Development, and Evaluations methodology.
Results: The choice of surgical intervention depends on stone characteristics, patient anatomy, comorbidities, and choice. For shockwave lithotripsy (SWL), the optimal shock frequency is 1.0–1.5 Hz. For ureteroscopy (URS), a postoperative stent is not needed in uncomplicated cases. Flexible URS is an alternative if percutaneous nephrolithotomy (PCNL) or SWL is contraindicated, even for stones >2 cm. For PCNL, prone and supine approaches are equally safe. For uncomplicated PCNL cases, a nephrostomy tube after PCNL is not necessary. Radiation exposure for endourological procedures should follow the as low as reasonably achievable principles.
Conclusions: This is a summary of the EAU urolithiasis guidelines on best clinical practice in interventional management of urolithiasis. The full guideline is available at https://uroweb.org/guidelines/urolithiasis.
Patient summary: The European Association of Urology has produced guidelines on the best management of kidney stones, which are summarised in this paper. Kidney stone

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disease is a common condition; computed tomography (CT) is increasingly used to diagnose it. The guidelines aim to decrease radiation exposure to patients by minimising the use of x-rays and CT scans. We detail specific advice around the common operations for kidney stones.

1. Introduction

Urolithiasis is becoming increasingly prevalent and is associated with a high economic burden [1–3]. The mainstays of definitive treatment for upper tract urolithiasis in the modern era are surgical (shockwave lithotripsy [SWL], rigid and flexible ureteroscopy [URS], and conventional/mini–percutaneous nephrolithotomy [PCNL]), with open procedures becoming relatively uncommon, although there is some use of laparoscopic/robotic surgery for stone removal [4]. Surgical technologies for treating urolithiasis have evolved dramatically in recent years with the introduction of increasingly small flexible ureteroscopes, disposable ureteroscopes, PCNL miniaturisation, and high-power holmium lasers, and the recent introduction of the thulium fibre laser (TFL). Current limitations in urolithiasis management are the lack of guidance on radiation exposure to both the patient and the practitioner, and areas of controversy within surgical management.

The European Association of Urology (EAU) guidelines have provided annual updated guidance on the management of urolithiasis since 2000. We aim to summarise the best clinical practice statements from the current guidelines for intervention and radiation exposure, and then discuss important areas of controversy where further research is needed.

2. Evidence acquisition

A professional research librarian (C.Y.) carried out literature searches for all sections of the urolithiasis guidelines from January 2011 to May 2021. Searches were conducted using the Cochrane library database of systematic review, Cochrane library of controlled clinical trials, Embase, and Ovid Medline. Searches were restricted to English-language articles only. This search is performed annually.

A strength rating is provided for each recommendation according to the EAU Guideline Office methodology (modified from the Grading of Recommendations, Assessment, Development, and Evaluations [GRADE] methodology [5]).

3. Evidence synthesis

3.1. Precautions for stone removal

3.1.1. Perioperative antibiotics

For infection prevention following URS or PCNL, no clear-cut evidence exists [6]. Urine culture should be sent for all patients prior to surgery as a part of preassessment. Single-dose administration at anaesthetic induction seems to be sufficient in preventing postoperative infection [7].

3.1.2. Management of anticoagulants

Patients receiving anticoagulant therapy should stop their anticoagulation at the appropriate time point before interventional stone management (see Table 1) [8]. In patients with a bleeding disorder, consultation with an internist is appropriate. In patients with an uncorrected bleeding disorder, the following are at an increased risk of haemorrhage or perinephric haematoma (high-risk procedures): SWL, PCNL, percutaneous nephrostomy, laparoscopic surgery, and/or open surgery [9].

SWL is feasible and safe after correction of the underlying coagulopathy [10]. In the case of an uncorrected bleeding disorder or continued antithrombotic therapy, URS, in contrast to SWL and PCNL, might offer an alternative approach since it is associated with less morbidity [11]. Although URS is safer, an individualised patient approach is necessary, and there is still a risk of bleeding if antithrombotic therapy is continued [11].

3.2. Shockwave lithotripsy

3.2.1. Stenting

Routine use of internal stents before SWL does not improve stone-free rates (SFRs), nor lowers the number of auxiliary treatments. It may, however, reduce formation of steinstrasse for SWL of larger stones (>1.5 cm) [12].

3.2.2. Pacemakers/implanted defibrillators

Patients with a pacemaker can be treated with SWL, provided that appropriate technical precautions are taken (programme the bradycardia pacing mode to a non–rate response VVI/VOO mode; if concerned about inappropriate shocks, consider deactivating the tachyarrhythmia detection portion). Patients with implanted cardioverter defibrillators must be managed with special care (firing mode temporarily reprogrammed during SWL treatment). This might not be necessary with new-generation lithotripters [13]; however, it might be safe practice to contact the local pacemaker/implantable cardioverter defibrillator technician for advice.

3.2.3. Shockwave rate

Lowering shockwave frequency from 120 to 60–90 shockwaves per minute improves SFRs (see Table 2) [14,15]. Tissue damage increases with shockwave frequency [16].

3.2.4. Number of shockwaves, energy setting, and repeat treatment sessions

The number of shockwaves that can be delivered at each session depends on the type of lithotripter and shockwave power. There is no consensus on the maximum number of

Table 1 – Perioperative anticoagulation guidance

Medication/ agent	Bleeding risk of planned procedure	Risk of thromboembolism		
		Low risk	Intermediate risk	High risk
Warfarin	Low-risk procedure	May be continued	Bridging therapy	Bridging therapy
Dabigatran	High-risk procedure	May be temporarily discontinued at appropriate interval (warfarin 5 d prior; DOAC 3 d prior)	Bridging therapy	Bridging therapy
Rivaroxaban		Bridging therapy is strongly recommended		
Apixaban				
Aspirin	Low-risk procedure	Continue	Continue	Elective surgery: postpone
				Nondeferrable surgery: continue
	High-risk procedure	Discontinue 3 d before intervention	Elective surgery: postpone	Elective surgery: postpone
			Nondeferrable surgery: continue, if it is possible	Nondeferrable surgery: continue
Thienopyridine agents (P2Y12 receptor inhibitors)	Low-risk procedure	Discontinue 5 d before intervention	Continue	Elective surgery: postpone
		Resume within 24–72 h with a loading dose		Nondeferrable surgery: continue
	High-risk procedure	Discontinue 5 d before intervention and resume within 24–72 h with a loading dose	Elective surgery: postpone	Elective surgery: postpone
			Nondeferrable surgery: discontinue 5 d before procedure and resume within 24–72 h with a loading dose	Nondeferrable surgery: discontinue 5 d before procedure and resume within 24–72 h, with a loading dose
			Bridging therapy—glycoprotein IIb/IIIa inhibitors if aspirin is discontinued	Bridging therapy—glycoprotein IIb/IIIa inhibitors

DOAC = direct oral anticoagulants.

Table 2 – Recommendations and evidence strength rating for extracorporeal shockwave lithotripsy (SWL)

Recommendations	Strength rating
Ensure correct use of the coupling agent because this is crucial for effective shockwave transportation.	Strong
Maintain careful fluoroscopic and/or ultrasonographic monitoring during SWL.	Strong
Use proper analgesia because it improves treatment results by limiting pain-induced movements and excessive respiratory excursions.	Strong
Prescribe antibiotics prior to SWL in the case of infected stones or bacteriuria.	Strong
Optimal shock wave frequency is 1.0–1.5 Hz	Strong
Use stepwise power ramping to prevent renal injury.	Strong

shockwaves [17]. Starting SWL on a lower energy setting with stepwise power ramping can achieve vasoconstriction during treatment [18], which prevents renal injury [19]. Animal studies [20] and one prospective randomised study [21] have shown better SFRs (96% vs 72%) using stepwise power ramping, but no difference has been found for fragmentation or evidence of complications after SWL, irrespective of whether ramping was used [22].

There are no conclusive data on the intervals required between repeated SWL sessions. However, there is some evidence indicating that repeat sessions are feasible (within 1 d for ureteral stones) [23].

3.2.5. *Improvement of acoustic coupling*

Proper acoustic coupling between the cushion of the treatment head and the patient's skin is important. Defects (air pockets) in the coupling gel deflect 99% of shockwaves [24]. Ultrasound (US) gel is the most widely used agent available as a lithotripsy coupling agent [25].

3.2.6. *Procedural control*

Results of treatment are operator dependent, and experienced clinicians obtain better results. During the procedure, careful imaging control of localisation contributes to improved outcome quality [26].

3.2.7. *Pain control*

Careful control of pain during treatment is necessary to limit pain-induced movements and excessive respiration [27].

3.2.8. *Antibiotic prophylaxis*

No standard antibiotic prophylaxis before SWL is recommended. However, prophylaxis is recommended in the case of internal stent placement ahead of anticipated treatments and in the presence of increased bacterial burden (eg, indwelling catheter, nephrostomy tube, or infectious stones) [28].

3.2.9. *Medical therapy after extracorporeal SWL*

Despite conflicting results, most randomised controlled trials (RCTs) and several meta-analyses support medical expulsive therapy (MET) after SWL for ureteral or renal

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stones as adjunct to expedite expulsion and to increase SFRs. MET might also reduce analgesic requirements [29].

3.2.10. Post-treatment management

Mechanical percussion and diuretic therapy can significantly improve SFRs and accelerate stone passage after SWL [30].

3.3. Ureteroscopy

3.3.1. Access to the upper urinary tract

Most interventions are performed under general anaesthesia, although local/spinal anaesthesia is possible (see Table 3) [31]. Intravenous sedation can be considered for female patients with distal ureteral stones [32]. Antegrade URS is an option for large, impacted, proximal ureteral calculi [33]. Reduced-diameter flexible ureteroscopes may provide similar vision, deflection, and manoeuvrability to standard flexible ureteroscopes, with potentially improved ureteric access in retrograde intrarenal surgery [34]. Disposable ureteroscopes provide similar safety and clinical effectiveness to reusable scopes. Concerns regarding their cost effectiveness and environmental sustainability remain [35].

3.3.2. Safety aspects

Fluoroscopic equipment must be available in the operating room. Placement of a safety wire is recommended. Balloon and plastic dilators should be available, if necessary.

Prior rigid URS can be helpful for optical ureteral dilatation followed by flexible URS, if necessary. If ureteral access is not possible, insertion of a JJ stent followed by URS after 7–14 d offers an alternative [36]. Bilateral URS during the same session is feasible, resulting in equivalent to lower SFRs, but slightly higher overall complication rates (mostly Clavien 1–2) [37]. Difficult lower pole anatomy such as a steep infundibulopelvic angle (<30°) predisposes to failure during retrograde intrarenal surgery [38]. Prolonged operative times are linked to increased complication rates, and efforts must be made to complete ureteroscopic surgery within 90 min.

Table 3 – Recommendations and evidence strength ratings for ureteroscopy (URS)

Recommendations	Strength rating
Use Ho:YAG laser lithotripsy for (flexible) URS.	Strong
Perform stone extraction only under direct endoscopic visualisation of the stone.	Strong
Do not insert a stent in uncomplicated cases.	Strong
Offer medical expulsive therapy for patients suffering from stent-related symptoms and after Ho:YAG laser lithotripsy to facilitate the passage of fragments.	Strong
Use percutaneous antegrade removal of ureteral stones as an alternative when SWL is not indicated or has failed, and when the upper urinary tract is not amenable to retrograde URS.	Strong
Use flexible URS in cases where percutaneous nephrolithotomy or SWL is not an option (even for stones >2 cm). However, in this case, there is a higher risk that a follow-up procedure and placement of a ureteral stent may be needed.	Strong

Ho:YAG = holmium:yttrium-aluminium-garnet; SWL = shockwave lithotripsy.

3.3.3. Ureteral access sheaths

Hydrophilic-coated ureteral access sheaths (UASs), which are available in different calibres (inner diameter ≥9 Fr), can be inserted (via guide wire) with the tip placed in the proximal ureter just below the pelviureteric junction. UASs allow multiple and easier access to the upper urinary tract and therefore significantly facilitate URS. The use of a UAS improves vision by establishing a continuous outflow, decreases intrarenal pressure (IRP), and potentially reduces operating time [39].

The insertion of a UAS may lead to ureteral damage, and the risk of injury is lowest in prestented systems [40]. No data on long-term complications are available [40]. Larger cohort series demonstrated no difference in SFRs and ureteral damage (stricture rates of ~1.8%), but significantly lower postoperative infectious complications [41]. The use of a UAS is safe and can be useful for large and multiple renal stones or if prolonged procedural time is expected [42].

3.3.4. Stone extraction

The aim of URS is complete stone removal. "Dust and go" strategies should be limited to the treatment of large renal stones [43]. Smaller stones/fragments can be extracted by endoscopic forceps or baskets. Only nitinol baskets can be used for flexible URS [44]. Although fragmentation with extraction is appealing, this may increase operative time and requires an extraction device and likely a UAS. In emergency cases with acute renal colic, if not infected, primary URS or SWL can be offered.

3.3.5. Intracorporeal lithotripsy

The most effective lithotripsy system is the holmium:yttrium-aluminium-garnet (Ho:YAG) laser, which is currently the optimum standard for URS and flexible renoscopy (see Section 3.4), because it is effective for all stone types [45]. Compared with lower-power lasers, high-power lasers reduce procedural time with no significant difference in clinical outcomes [46]. Pneumatic and US systems can be used with high disintegration efficacy in rigid URS [47]. However, proximal stone migration is a common problem, which can be prevented by placement of antimigration tools proximal to the stone. TFL for stone disease is discussed in Section 4.6.

New laser properties (MoSES, Virtual Basket, Vapor Tunnel, and Bubble Blast) may improve stone interaction [48].

3.3.6. Stenting before and after URS

Routine ureteral stenting is unnecessary before URS. However, prestenting facilitates ureteroscopic management of stones, improves SFRs, and reduces intraoperative complications [49].

RCTs have found that routine ureteral stenting after uncomplicated URS (complete stone removal) is unnecessary and may be associated with higher postoperative morbidity and costs [50]. A ureteral catheter with a shorter indwelling time (24 h) may also be used [51]. Ureteral stents should be inserted in patients who are at an

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increased risk of complications (eg, ureteral trauma, residual stone fragments, bleeding, perforation, urinary tract infections, or pregnancy) and in all doubtful cases, to avoid subsequent emergencies. Ideal stent duration is not known. Most urologists favour 1–2 wk of post-URS stenting. Alpha-blockers may reduce morbidity and increase tolerability of ureteral stents [52].

3.3.7. *MET before and after URS*

MET before URS might reduce the need for intraoperative ureteral dilatation, protect against ureteral injury, and increase SFRs up to 4 wk after URS. MET following Ho:YAG laser lithotripsy accelerates the spontaneous passage of fragments and reduces episodes of colic [53].

3.4. *Percutaneous nephrolithotomy*

3.4.1. *Preoperative imaging*

Renal US or computed tomography (CT) can provide information regarding interpositioned organs and structures within the planned percutaneous path (eg, spleen, liver, large bowel, pleura, ribs, and lung) (see Table 4).

3.4.2. *Positioning of the patient*

Both the prone and the supine position are equally safe and have similar SFRs. The prone position offers more options/surface area for punctured access and is therefore preferred for upper pole or multiple accesses [54]. Conversely, the supine position allows simultaneous retrograde access to the collecting system, using flexible URS for endoscopic combined intrarenal surgery (ECIRS) [50].

3.4.3. *Puncture*

Although fluoroscopy is the most common intraoperative imaging method, the (additional) use of US reduces radiation exposure [51]. Preoperative CT or intraoperative US allows identification of the tissue between the skin and the kidney, and lowers the incidence of visceral injury [55]. The calyceal puncture may be done under direct visualisation using simultaneous flexible URS [56].

Table 4 – Recommendations and evidence strength rating for percutaneous nephrolithotomy (PCNL)

Recommendations	Strength rating
Both prone and supine positions are equally safe, but neither has a proven advantage in operating time or SFR.	Strong
Perform preprocedural imaging, including contrast medium where possible or retrograde study when starting the procedure, to assess stone comprehensiveness and anatomy of the collecting system to ensure safe access to the renal stone.	Strong
Perform a tubeless (without a nephrostomy tube) or totally tubeless (without a nephrostomy tube and a ureteral stent) percutaneous nephrolithotomy procedure in uncomplicated cases.	Strong
Instrument choice (standard, mini-, or micro-PCNL) should be operator/patient dependent. Smaller instruments tend to be associated with significantly lower blood loss, but the duration of procedure tended to be significantly longer. There are no significant differences in SFR or any other complications.	Strong
Perform PCNL to remove large renal stones in patients with urinary diversion, as well as for ureteral stones that cannot be accessed via a retrograde approach or that are not amenable to shockwave lithotripsy.	Strong

SFR = stone-free rate.

3.4.4. *Tract dilatation*

Dilatation of the percutaneous access tract can be achieved using a metallic endoscope, single (serial) dilators, or a balloon dilatator. During PCNL, safety and effectiveness are similar for different tract dilatation methods [57]. There are data demonstrating that single-step dilation is equally effective as other methods and that only US can be used for the dilatation. Difference in outcomes is likely related to surgeon experience rather than the technology used [58].

3.4.5. *Choice of instruments*

SFRs are comparable in miniaturised (≤20 Fr, mini-PCNL) and standard PCNL procedures [59,60]. Procedures performed with smaller instruments are associated with significantly lower blood loss, but the duration of procedure is significantly longer. There were no significant differences in any other complications. However, evidence quality is poor with a high risk of bias and few RCTs.

3.4.6. *Intracorporeal lithotripsy*

Ultrasonic and pneumatic systems are most commonly used for rigid nephroscopy, whilst laser lithotripsy is increasingly used for miniaturised instruments [61]. Flexible endoscopes also require laser lithotripsy to maintain tip deflection, with the Ho:YAG laser having become the standard laser modality.

3.4.7. *Use of suction*

There is some evidence of using suction during PCNL to reduce IRP and increase SFR [62].

3.4.8. *Nephrostomy and stents*

The decision on whether, or not, to place a nephrostomy tube at the conclusion of the PCNL procedure is dependent on several factors:

1. Presence of residual stones
2. Likelihood of a “second-look” procedure
3. Significant intraoperative blood loss
4. Urine extravasation
5. Ureteral obstruction
6. Potential persistent bacteriuria due to infected stones
7. Solitary kidney
8. Bleeding diathesis

Small-bore nephrostomies seem to reduce postoperative pain [59]. Tubeless PCNL is performed without a nephrostomy tube. When neither a nephrostomy tube nor a ureteral stent is introduced, the procedure is considered completely tubeless [63]. In uncomplicated cases, the latter procedure results in a shorter hospital stay, with no disadvantages reported [64].

3.5. *Radiation exposure and protection to patients and staff*

3.5.1. *Patient’s exposure to radiation*

Urolithiasis diagnosis and treatment are associated with exposure to high levels of ionising radiation [65]. Currently, there are no studies estimating the lifetime radiation exposure of stone formers or the subsequent malignancy development risk. Current evidence from patients exposed to atomic bomb radiations [66], retrospective epidemiological data on medical exposure [67], and modelling studies [68] suggest an age- and dose-dependent risk of secondary malignancy from ionising radiation. The use of ionising radiation should be minimised in stone formers.

3.5.2. Staff exposure to radiation

Availability of fluoroscopy is mandatory for endourological procedures, and therefore staff radiation exposure has been studied extensively. However, there are no studies assessing the risk of radiation-induced malignancies in urology staff [69]. The International Commission on Radiological Protection recommends a maximum annual occupational exposure of 50 mSv [70]. However, the risk of radiation-induced malignancy is stochastic with no known safe threshold of exposure. Taking this into consideration as well as the length of a urologist's career, the annual upper limit of 50 mSv is highly concerning.

There is increasing interest in fluoroscopy-free operations. Several RCTs have been published, showing a good outcome in terms of SFRs and complication rates [26]. These trials have been limited to noncomplex cases, and these were not sufficiently powered to show noninferiority of fluoroscopy in PCNL [71] or superiority of US in URS [72]. Therefore, the current recommendation is to use fluoroscopic guidance when performing endourological procedures, whilst using all necessary personal protective equipment (ie, lead aprons, thyroid protector, and lead goggles/glasses).

4. Discussion

4.1. General comments

Overall, our recommendations carry variable strength recommendations as per the modified GRADE criteria [5]. Given the variable quality of evidence available, the panel has had to up/downgrade recommendations depending on multiple factors including effect size and risk of bias, along with the panel's consensus opinion, as per the GRADE methodology. This is where the difficulties lie in creating and curating high-quality guidelines, especially given the diversity of clinical scenarios reported and the wide variation in definitions, for example, stone-free status. It is clear that for most scenarios, high-quality evidence is still lacking. We highlight key areas for urgent high-quality evidence acquisition in the following sections.

4.2. Post-treatment management of SWL

A number of methods have been described for aiding stone passage after SWL (regardless of stone location), including mechanical percussion, diuretic therapy, and use of alpha-blockers.

There have been a small number of small trials comparing mechanical percussion with placebo [56]. A meta-analysis of these trials demonstrated minimal heterogeneity, no evidence of publication bias, and significant benefits in successful stone clearance [66]. There was no difference in the average number of sessions per stone or the average number of shocks per stone. A subsequent trial has demonstrated similar effects [26]; however, further high-quality, appropriately powered trials with a subsequent meta-analysis are needed to address this question definitively.

There is evidence from meta-analyses that shows an increased stone clearance rate with diuretics [56,57]. These reviews consisted of small studies that had a moderate risk of bias, and therefore more evidence is needed before a recommendation can be made.

A recent Cochrane review of 40 RCTs examining the post-SWL use of alpha-blockers reported that there were possible improvements in the clearance of stone fragments, reduced need for auxiliary treatments, reduced major adverse events, and reduced time to stone clearance [58]. However, they acknowledge that there is a low certainty of evidence and therefore the actual effect may be significantly different from that reported.

4.3. Video versus fibre-optic versus disposable flexible ureteroscopes

Traditional flexible ureteroscopes convey picture via fibre optics; however, more recently, fully integrated digital video ureteroscopes have become available. There is debate in the literature about the optimal use of video versus fibre-optic scopes, with more novel videoscopes being disposable [73,74].

There is conflicting evidence for the superiority of one scope type over another. A cadaveric study demonstrated that all three types of scopes were comparable, with the reusable digital scopes subjectively providing the best image quality, but the fibre-optic and disposable digital scopes providing the best manoeuvrability [73]. In vitro, disposable digital scopes demonstrated superior, albeit marginal, flexion/deflection and flow rates to reusable scopes [75]. Further fibre-optic scopes have a demonstrably superior ability to access the lower pole, due to larger deflection angles [76]. There is also in vivo evidence from an RCT that, as fibre-optic scopes have a smaller diameter, the need for a ureteric access sheath is significantly less than that with a digital scope [77]. Reducing the need for an access sheath reduces the risk of ureteric wall damage [40].

There are also arguments surrounding the cost and environmental impact of reusable versus disposable scopes. Owing to the high purchase, sterilisation, and repair costs of reusable scopes, disposable scopes are arguably more cost effective, especially for high-volume centres [78]. Disposable scopes have also been demonstrated to have similar, if not less, environmental impact to reusables [79]. However, for both of these aspects, there is minimal evidence and no meta-analyses; therefore, recommendations regarding which scope to use remains unclear. Given the benefits of differing scopes, the type of scope used might have to be individualised to the patient and potentially having several scope types available for different scenarios may be helpful.

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4.4. IRP in endourological procedures

There is a large body of evidence that suggests that sustained high (>40 cmH_2O) IRP is a major contributor to the development of postoperative complications in endourological procedures (URS/PCNL) [80]. In URS, the use of a UAS decreases the IRP proportional to the diameter of the sheath [80]. Miniaturisation of PCNL has also been associated with increased IRP in mini- and micro-PCNL [80]. For both procedures, novel sensor wires are being developed so that real-time monitoring of IRP will be available in the near future [81]. However, this remains an experimental tool. Until this is standardised, urologists should be wary of the high IRP associated with URS/PCNL and the potential complications that can arise because of this.

4.5. Role of suction in endourological procedures

Suction has traditionally been used only in PCNL. However, novel suction devices have been developed to allow suction in mini-PCNL and URS [62]. There have been several comparative studies of suction versus no suction, although no meta-analysis has been undertaken as yet. In mini-PCNL, the addition of suction reportedly reduces fever rates and operative time significantly, whilst increasing SFR [82].

For URS, suction devices have been developed that are integrated with a UAS. There has been only one comparative study between traditional UASs and suction UASs, which was retrospective and nonrandomised [83]. This demonstrated significantly reduced procedural time, higher immediate SFRs, and reduced postoperative fever rates. However, 1-mo SFRs and sepsis rates did not differ. It is evident that further evidence is needed in this area before this technology is adopted more widely.

4.6. TFL versus Ho:YAG laser

The Ho:YAG laser has become the gold standard for intracorporeal lithotripsy due to its efficacy and safety profile compared with historic lithotripsy techniques. However, a new fibre laser system based on thulium has recently been developed. This system offers several advantages, including a smaller, quieter machine and the ability to use existing power sockets. There are reports that TFL systems provide faster lithotripsy rates than Ho:YAG laser systems in both in vitro [84] and, more recently, in vivo studies [85]. There are also in vitro reports of shorter noncontact working distances [83] and minimal retropulsion [86], although these effects have yet to be reported in vivo. However, there have been reports of excessive bubble formation [87] and a "charring" effect [88]. There is a single small randomised trial comparing the outcomes of low-power Ho:YAG laser with those of TFL [89]. Further larger-scale multicentre trials are needed before recommending one over another.

4.7. MET before and after URS

There is conflicting evidence surrounding the use of MET in the context of URS. A recent systematic review on the preureteroscopic use of MET has demonstrated benefits in operative time, reduced need for intraoperative ureteral dilatation, and enhanced SFRs at both 4 wk and final follow-up [90]. However, the authors of this study noted the moderate quality of evidence and high risk of bias.

The postureteroscopic use of MET has been studied in a few small RCTs, a meta-analysis of which demonstrated higher SFRs but no significant difference in readmissions [91]. There have been no Cochrane reviews on the use of MET following URS, but there have been reviews for MET use after SWL and in acute colic. After SWL, there was low-grade evidence of a modest improvement in SFRs, but the authors note that there was a significant publication bias [92]. This publication bias towards MET benefit was also reflected in the extensive literature on MET in acute colic [93]. Further high-quality trial-based evidence is needed before a recommendation of pre- or postureteroscopic MET can be endorsed.

4.8. Prone versus supine for PCNL

Traditionally, patients were placed in the prone position for PCNL. However, there has been an increasing use of the supine position. This position also allows for simultaneous URS, that is, ECIRS. There is good evidence from a meta-analysis of RCTs showing no significant differences in complication rates or SFRs between the prone and supine positions, with no evidence of a publication bias [61]. Therefore, either technique can be used as per clinician/patient preference.

4.9. Renal stones >2 cm—URS versus PCNL

Large renal stones (>2 cm) have traditionally been treated with PCNL. However, with advances in ureteroscopic technology, there are reports of large stones being treated with URS [94]. Unfortunately, there are no comparative studies between the two approaches, and therefore the safety and efficacy between the two have yet to be definitely established. We recommend a large, well-powered RCT to address this particular issue. Until further evidence to the contrary is available, the current recommendation remains that PCNL be used over URS for large stones.

4.10. Operating in the context of SARS-CoV-2

The SARS-Cov-2 (COVID-19) pandemic is causing major disruption to waiting lists and procedures surrounding operations. There is evidence that in patients infected with SARS-Cov-2, the risk of pulmonary complications and 30-d mortality are higher than in those not infected, regardless of the procedure type (minor/major, elective/emergency) [95]. Given this evidence and the availability of testing, the panel recommends a polymerase chain reaction or lateral flow test prior to surgery. Should this prove positive, then the procedure should be rearranged if clinically safe to do so.

4.11. Treatment of nonindex patients

Recommendations for the treatment of nonindex patients (renal transplant, solitary kidney, horseshoe kidney, ectopic kidney, etc.) are available in the full guidelines [96].

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5. Conclusions

The present text represents a summary of the 2022 EAU urolithiasis guidelines pertaining to the “best clinical practice” for the treatment of urolithiasis. We summarise the current best practice for operative management of urolithiasis.

***Author contributions*:** Andreas Skolarikos had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Skolarikos, Turk.
Acquisition of data: Tzelves, Lombardo, Yuan.
Analysis and interpretation of data: Tzelves, Geraghty.
Drafting of the manuscript: Tzelves, Geraghty, Skolarikos.
Critical revision of the manuscript for important intellectual content: Skolarikos, Thomas, Petrik, Gambaro, Neisius, Somani, Davis.
Statistical analysis: Geraghty, Tzelves.
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