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Platinum Priority – Guidelines

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EAU Guidelines on Interventional Treatment for Urolithiasis

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Abstract

Context: Management of urinary stones is a major issue for most urologists. Treatment modalities are minimally invasive and include extracorporeal shockwave lithotripsy (SWL), ureteroscopy (URS), and percutaneous nephrolithotomy (PNL). Technological advances and changing treatment patterns have had an impact on current treatment recommendations, which have clearly shifted towards endourologic procedures. These guidelines describe recent recommendations on treatment indications and the choice of modality for ureteral and renal calculi.
Objective: To evaluate the optimal measures for treatment of urinary stone disease.
Evidence acquisition: Several databases were searched to identify studies on interventional treatment of urolithiasis, with special attention to the level of evidence.
Evidence synthesis: Treatment decisions are made individually according to stone size, location, and (if known) composition, as well as patient preference and local expertise. Treatment recommendations have shifted to endourologic procedures such as URS and PNL, and SWL has lost its place as the first-line modality for many indications despite its proven efficacy. Open and laparoscopic techniques are restricted to limited indications. Best clinical practice standards have been established for all treatments, making all options minimally invasive with low complication rates.
Conclusion: Active treatment of urolithiasis is currently a minimally invasive intervention, with preference for endourologic techniques.
Patient summary: For active removal of stones from the kidney or ureter, technological advances have made it possible to use less invasive surgical techniques. These interventions are safe and are generally associated with shorter recovery times and less discomfort for the patient.

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1. Introduction

The latest print versions of the European Association of Urology (EAU) guidelines for the diagnosis and treatment of urolithiasis were published in 2001 for renal stones [1] and in 2007 for ureteral stones [2], but online updates have been published annually [3]. The EAU guidelines on imaging and conservative management of urolithiasis and on paediatric urolithiasis will be published separately. The EAU guideline on metabolic evaluation and prevention has been published

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recently [4]. Technological developments are continuously influencing the choice of therapeutic options. This paper summarises current recommendations for the treatment of upper urinary tract stones.

2. Evidence acquisition

A professional research librarian carried out literature searches for all sections of the urolithiasis guidelines covering the period up to August 2014. Searches were carried out using the Cochrane Library Database of Systematic Reviews, the Cochrane Library of Controlled Clinical Trials, and Medline and Embase on the Dialog–Datastar platform. The searches used the controlled terminology of the respective databases. Both MesH and Emtree were analysed for relevant terms. In many cases, use of free text ensured the sensitivity of the searches. The focus of the searches was identification of all level 1 scientific papers (systematic reviews and meta-analyses of randomised controlled trials [RCTs]). If sufficient data were identified to answer the clinical question, the search was not expanded to include lower-level literature. Level of evidence (LE) and/or grade of recommendation (GR) were determined according to the Oxford Centre for Evidence-based Medicine [5]. In some cases there was no direct link between LE and GR, and recommendations were upgraded or downgraded following expert panel discussion. These cases are clearly identifiable and denoted in the recommendations with an asterisk.

3. Evidence synthesis

3.1. Indications for active stone removal and procedure selection

Indications for active stone removal of renal stones are as follows:

- Stone growth
- Size >15 mm
- Stones <15 mm if observation is not the option of choice
- Patients at high risk of stone formation
- Obstruction caused by stones
- Infection
- Symptomatic stones
- Comorbidity
- Social situation or patient choice (eg, profession or travel)

Indications for active removal of ureteral stones are as follows:

- Low likelihood of spontaneous passage
- Persistent pain despite adequate analgesia
- Persistent obstruction
- Renal insufficiency

3.1.1. Selecting a procedure for active removal of kidney stones

Shockwave lithotripsy (SWL), percutaneous nephrolithotomy (PNL), and ureteroscopy (URS) are suitable treatment modalities for renal calculi (Table 1). PNL efficacy is little affected by stone size, while the stone-free rates (SFRs) after SWL or URS are inversely proportional to stone size [6,7]. Flexible URS has lower SFRs for stones >20 mm, and staged procedures are often required. Stones >20 mm should therefore be treated primarily by PNL because SWL often requires multiple treatments [8]. SWL achieves good SFRs for stones ≤20 mm, except for those at the lower pole [9,10], for which endourology is considered an alternative (Fig. 1). Negative predictors of SWL success are given in Table 2. The value of supportive measures to improve SWL outcome, such as inversion, vibration, and hydration, remains a matter of discussion [11,12]. Open or laparoscopic approaches are possible alternatives if other treatment modalities fail or are not available.

Table 1 – Recommendations for active treatment of renal calculi

Recommendation	GR
SWL and endourology (PNL and URS) are treatment options for renal stones <2 cm	B
Stones >2 cm should be treated by PNL	A
Flexible URS is a possible second-line treatment for large stones (>2 cm) but SFRs are lower and staged procedures may be required	B
PNL or flexible URS is recommended for the lower pole, even for stones >1.5 cm, because SWL efficacy is limited	B

GR = grade of recommendation; PNL = percutaneous nephrolithotomy; SFR = stone-free rate; SWL = extracorporeal shock wave lithotripsy; URS = ureteroscopy.

3.1.2. Selecting a procedure for active removal of ureteral stones

Overall SFRs after URS or SWL for ureteral stones are comparable. Patients should be informed that URS has a better chance of achieving stone-free status with a single procedure, but has higher complication rates [13].

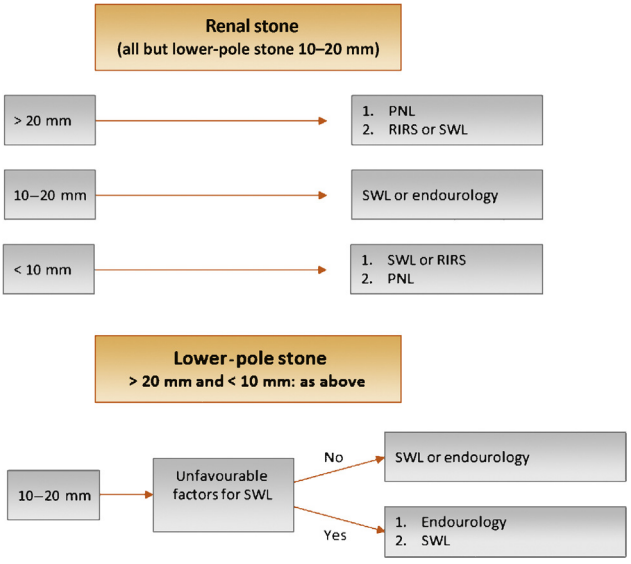

Fig. 1 – Treatment algorithm for renal calculi.
PNL = percutaneous nephrolithotomy; RIRS = retrograde intrarenal surgery; SWL = extracorporeal shock wave lithotripsy.

Table 2 – Unfavourable factors for extracorporeal shockwave lithotripsy success [59]

Shockwave-resistant stones (calcium oxalate monohydrate, brushite, or cystine)
Steep infundibular-pelvic angle
Long lower-pole calyx (>10 mm)
Narrow infundibulum (<5 mm)

Table 3 – Recommendations for antibiotic therapy and prevention of septic complications

Recommendations	LE	GR
A urine culture or urinary microscopy is mandatory before any treatment		A
UTIs must be treated before all endourologic stone removal procedures	1b	A
Perioperative antibiotic prophylaxis is recommended for URS and PNL. Single-dose administration is sufficient	1b	A*

GR = grade of recommendation; LE = level of evidence; UTIs = urinary tract infections; URS = ureteroscopy; PNL = percutaneous nephrolithotomy.

Table 4 – Recommendations for anticoagulation therapy

Recommendations	LE	GR
In patients at high risk of complications (due to antithrombotic therapy) in the presence of an asymptomatic calyceal stone, active surveillance should be offered		C
Temporary discontinuation or bridging of antithrombotic therapy in high-risk patients should be decided in consultation with the internist	3	B
Antithrombotic therapy should be stopped before stone removal after assessing the thrombotic risk	3	B
If stone removal is essential and antithrombotic therapy cannot be discontinued, URS is the preferred approach since it is associated with lower morbidity	2a	A*

LE = level of evidence; GR = grade of recommendation; URS = ureteroscopy.

Table 5 – Stone removal in obese patients

Evidence summary	LE
In cases of severe obesity, URS is a more promising therapeutic option than SWL [19]	2b

LE = level of evidence; URS = ureteroscopy; SWL = extracorporeal shock wave lithotripsy.

Table 6 – Recommendations for assessing stone composition before treatment

Recommendations	LE	GR
The stone composition should be evaluated before deciding on the method of removal (based on patient history, prior stone analysis for the patient or HU in unenhanced computed tomography)	2a	B
In stones with a medium density >1000 HU, SWL is not recommended since disintegration will be less likely	1	A
In uric acid stones, chemolysis can be considered	2a	B

HU = Hounsfield units; GR = grade of recommendation; LE = level of evidence; SWL = extracorporeal shock wave lithotripsy.

Table 7 – Recommendations for treatment of stones in pregnancy

Recommendations	LE	GR
Conservative management should be first-line treatment for all noncomplicated cases of urolithiasis in pregnancy (except those that have clinical indications for intervention)		A
Regular follow-up until final stone removal is strongly recommended owing to the higher encrustation tendency of stents during pregnancy	3	A

GR = grade of recommendation; LE = level of evidence.

3.2. *General recommendations for stone removal*

3.2.1. *Antibiotic therapy*

Urinary tract infections (UTIs) should always be treated if stone removal is planned (Table 3). In patients with a clinically significant infection and obstruction, the kidneys should be drained for several days first.

3.2.2. *Perioperative antibiotic prophylaxis*

Single-dose antibiotic administration is sufficient for URS [14]. Antibiotic prophylaxis significantly reduces the rate of fever after PNL, even in patients with a negative baseline urine culture [15]. As for URS, single-dose application seems to be sufficient (Table 3). No standard antibiotic prophylaxis before SWL is recommended, except in cases with a higher risk of bacterial burden (eg, indwelling catheter, nephrostomy tube, or infectious stones) [16].

3.2.3. *Anticoagulation therapy*

Patients with uncorrected bleeding diathesis undergoing stone intervention are at higher risk of haemorrhage (Table 4) [17]. There is no evidence supporting the safety of low-dose acetylsalicylates.

3.2.4. *Obesity*

Obese patients have a higher anaesthesia risk and a lower success rate after SWL and PNL (Table 5) [18].

3.2.5. *Stone composition*

Stones composed of brushite, calcium oxalate monohydrate, or cystine are particularly hard [20] and PNL and URS are more effective alternatives (Table 6).

3.2.6. *Pregnancy*

If spontaneous passage does not occur or if complications develop, placement of a ureteral stent or a percutaneous nephrostomy tube is necessary (LE 3) [21]. However, because such temporary therapies are often associated with poor tolerance, URS has become a reasonable alternative in these situations (LE 1a) (Table 7) [22].

3.2.7. *Residual stones*

The recurrence risk is higher in patients with residual fragments after treatment of infection stones than for other stones [23]. Fragments >5 mm are more likely than smaller ones to require intervention [24]. The indications for active

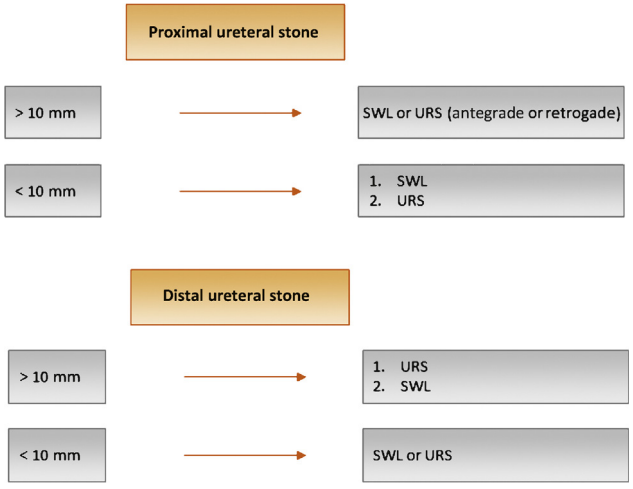

Fig. 2 – Treatment algorithm for ureteral calculi.
SWL = extracorporeal shockwave lithotripsy; URS = ureteroscopy.

removal of residual stones and selection of the procedure are based on the same criteria as for primary stone treatment and includes repeat SWL [25].

3.3. *Modalities for active stone removal (Fig. 2)*

3.3.1. *Extracorporeal SWL*

Contraindications to the use of SWL include:

- Pregnancy
- Bleeding diatheses or anticoagulation
- Uncontrolled UTI

Table 8 – Recommendations for best clinical practice in shock wave lithotripsy

Recommendations	LE	GR
The optimal shockwave frequency is 1.0–1.5 Hz	1a	A
Ensure correct use of the coupling gel because this is crucial for effective shockwave transport	2a	B
Use proper analgesia because it improves treatment results by limiting induced movements and excessive respiratory excursions [30]	4	C
Maintain careful fluoroscopic and/or ultrasonographic monitoring during the procedure	4	A*

LE = level of evidence; GR = grade of recommendation.
* Upgraded based on panel consensus.

Table 9 – Recommendations for follow-up after active stone removal

Recommendations	LE	GR
Patients with residual fragments or stones should be followed up regularly to monitor disease course	4	C
After SWL and URS, and in the presence of residual fragments, MET is recommended using an α-blocker to improve fragment clearance	1a	A

LE = level of evidence; GR = grade of recommendation; SWL = extracorporeal shock wave lithotripsy; URS = ureteroscopy; MET = medical expulsive therapy.

Table 10 – Recommendation on routine stenting in SWL

Recommendation	LE	GR
Routine stenting is not recommended as part of SWL treatment of ureteral stones [26]	1b	A

LE = level of evidence; GR = grade of recommendation; SWL = extracorporeal shock wave lithotripsy.

- Severe skeletal malformations and severe obesity, which prevent targeting of the stone
- Arterial aneurysm in the vicinity of the stone
- Anatomical obstruction distal to the stone

3.3.1.1. Best clinical practice. Lowering the shockwave frequency from 120 to 60–90 shock waves/min improves the SFR [27,28]. The number of shock waves that can be delivered at each session depends on the type of lithotripter and shockwave power. Stepwise power ramping prevents renal injury [29].

Recommendations to improve acoustic coupling and manage pain control are also included in Table 8.

3.3.1.2. Medical expulsive therapy after extracorporeal SWL. Medical expulsive therapy after SWL for ureteral or renal stones can expedite expulsion, increase SFR, and reduce additional analgesic requirements (Table 9) [31,32].

3.3.1.3. Complications of extracorporeal SWL. Compared to PNL and URS, there are fewer overall complications with SWL (Table 10) [33].

3.3.2. *Percutaneous nephrolithotomy*

For PNL, endoscopes of different sizes are available. The efficacy of miniaturised systems seems to be high, but no benefit compared to standard PNL for selected patients has yet been demonstrated [34].

3.3.2.1. Contraindications. Anticoagulant therapy must be discontinued before PNL [35]. Other important contraindications include untreated UTI, tumour in the presumptive access tract area, potential malignant kidney tumour, and pregnancy.

3.3.2.2. Positioning of the patient. Prone and supine positions are equally safe. Most studies cannot demonstrate an advantage of supine PNL in terms of operating time [36]. In some series, the SFR is lower for the supine than the prone position despite a longer operating time [36]. The prone position offers more options for puncture and is therefore preferred for upper-pole or multiple access [37].

3.3.2.3. Access. Colon interposition in the PNL access tract can lead to colon injuries. Preoperative computed tomography or intraoperative ultrasound allows identification of the tissue between the skin and kidney and lowers the incidence of bowel injury [38].

3.3.2.4. Dilation. Tract dilation can be achieved using a metallic telescope or a single or balloon dilator. Differences

Table 11 – Recommendation for nephrostomy or stent placement in PNL

Recommendation	LE	GR
In uncomplicated cases, tubeless (without PCN) or totally tubeless (without PCN and ureteral stent) PNL procedures provide a safe alternative.	1b	A

LE = level of evidence; GR = grade of recommendation; PCN = percutaneous nephrostomy; PNL = percutaneous nephrolithotomy.

Table 12 – Complications following percutaneous nephrolithotomy [60]

Complication	Frequency, % (range) (n = 11 929)
Transfusion	7 (0–20)
Embolisation	0.4 (0–1.5)
Urinoma	0.2 (0–1)
Fever	10.8 (0–32.1)
Sepsis	0.5 (0.3–1.1)
Thoracic complications	1.5 (0–11.6)
Organ injury	(0.4 (0–1.7)
Death	0.05 (0–0.3)

in outcomes are less related to the technology used than to the experience of the surgeon [40].

3.3.2.5. Intracorporeal lithotripsy. Ultrasonic and pneumatic systems are most commonly used for rigid nephroscopy (GR A*), while lasers are usually used in miniaturised and flexible instruments (LE 2a) [34]. Electrohydraulic lithotripsy is not considered to be a first-line technique owing to possible collateral damage [41].

3.3.2.6. Nephrostomy and stents. The decision about percutaneous nephrostomy (PCN) placement depends on: residual stones, likelihood of a second-look procedure, intraoperative bleeding, perforation, ureteral obstruction, potential bacteriuria due to infected stones, solitary kidney, and bleeding diathesis (Table 11). Small-bore PCN seem to cause less postoperative pain [42].

3.3.2.7. Complications. The most common postoperative complications associated with PNL are fever, bleeding, urinary leakage, and problems due to residual stones (Table 12). Perioperative fever can occur, even with a sterile preoperative urinary culture and perioperative antibiotic prophylaxis, because the kidney stones themselves may be a source of infection [43]. Bleeding after PNL may be treated by brief clamping of the PCN. Superselective embolic occlusion of an arterial branch may become necessary in cases of severe bleeding.

3.3.3. Ureteroscopy

Technical improvements and the introduction of a wide range of disposables have led to increased use of URS. Major technological progress has been achieved for flexible ureteroscopy, including improvements in (digital) imaging quality, resulting in shorter operating times [44–46]. The

Table 13 – Recommendation for percutaneous removal of ureteral stones

Recommendation	GR
Percutaneous antegrade removal of ureteral stones is an alternative when SWL and URS are not indicated or have failed [39]	A

GR = grade of recommendation; SWL = extracorporeal shock wave lithotripsy; URS = ureteroscopy.

Table 14 – Recommendation for best clinical practice in URS

Recommendation	GR
Placement of a safety wire is recommended.	A*

GR = grade of recommendation.

current standard for rigid uretero(reno)scopes are tip diameters of <8 F. Rigid or flexible URS can be used for the whole ureter, depending on individual anatomy and surgeon preference [2].

3.3.3.1. Contraindications. Apart from general problems such as general anaesthesia or untreated UTIs, URS can be performed in all patients without any specific contraindications (Table 13).

3.3.3.2. Best clinical practice. For safety reasons, fluoroscopic equipment must be available in the operating theatre. We recommend placement of a safety wire (Table 14) [47]. Dilators are available if necessary [48]. If insertion of a flexible URS is difficult, a prior rigid URS can be helpful for optical dilation. If ureteral access is not possible, insertion of a JJ stent several days before the second attempt offers an alternative to dilation [49].

3.3.3.3. Ureteral access sheaths (UASs). UASs of different calibre can be inserted via a guide wire, with the tip placed in the proximal ureter. UASs allow easy multiple access to the upper urinary tract. UAS use decreases intrarenal pressure, improves vision by establishing a continuous outflow, and potentially reduces operating time [50]. UAS insertion may lead to ureteral damage; the risk is lowest in prestented systems [51].

3.3.3.4. Stone extraction. The aim of URS is complete stone removal. Dusting strategies should be limited to the treatment of large renal stones. Stones can be extracted with endoscopic forceps or baskets. Only baskets made of nitinol can be used for flexible URS [52]. Blind basketing should not be performed (LE 4, GR 4*).

3.3.3.5. Intracorporeal lithotripsy. The most effective lithotripsy system is the Ho:YAG laser (Table 15) [53]. Pneumatic and ultrasound systems can be used with high disintegration efficacy in rigid URS [54].

3.3.3.6. Stenting. Routine stenting is not necessary before URS. However, prestenting facilitates URS management of

Table 15 – Recommendation for intracorporeal lithotripsy

Recommendation	LE	GR
Ho:YAG laser lithotripsy is the preferred method for (flexible) URS.	3	B

LE = level of evidence; GR = grade of recommendation; URS = ureteroscopy.

Table 16 – Recommendations for open and laparoscopic stone removal

Recommendation	LE	GR
Laparoscopic or open surgical stone removal may be considered in rare cases in which SWL, URS, and PNL fail or are unlikely to be successful	3	C
When expertise is available, laparoscopic surgery should be the preferred option before proceeding to open surgery. Exceptions are a complex renal stone burden and/or stone location	3	C
For ureterolithotomy, laparoscopy is recommended for large impacted stones when endoscopic lithotripsy or SWL has failed	2	B

stones, improves the SFR, and reduces complications [55]. RCTs have found that routine stenting after uncomplicated URS is not necessary; stenting might be associated with higher postoperative morbidity (LE 1a) [56]. However, stents should be inserted in patients who are at higher risk of complications (eg, ureteral trauma, residual fragments, or perforation). The ideal stenting duration is not known, but most urologists favour 1–2 wk after URS. α-Blockers seem to improve ureteral stent tolerability (LE 1a) [57].

3.3.3.7. Complications. The overall complication rate after URS is 9–25% [2,13]. Most complications are minor and do not require intervention. Ureteral avulsion and strictures are rare (<1%).

3.3.4. Open and laparoscopic surgery for removal of ureteral and renal stones

Currently, indications for open or laparoscopic stone surgery are rare (Table 16) [58]. However, open or laparoscopic surgery may be a valid treatment option if percutaneous approaches are not likely to be successful, or if endourologic approaches have been performed unsuccessfully, especially in cases with a centrally located renal stone mass.

4. Conclusions

Treatment decisions are made individually on the basis of stone size, location, and (if known) composition, patient preference, and local expertise. However, treatment recommendations have shifted to URS and PNL endourologic procedures, and extracorporeal SWL has lost its place as the first-line modality for most renal and ureteral stones, even though it is still effective. Open and laparoscopic techniques are restricted to limited indications. Best clinical practice standards have been established for all treatments, and all options are minimally invasive with low complication rates.

Author contributions: Thomas Knoll 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: Knoll, Türk, Petřk, Sarica, Seitz, Skolarikos, Straub.
Acquisition of data: Knoll, Türk, Petřk, Sarica, Seitz, Skolarikos, Straub.
Analysis and interpretation of data: Türk, Knoll, Petrik, Sarica, Seitz, Skolarikos, Straub.
Drafting of the manuscript: Knoll.
Critical revision of the manuscript for important intellectual content: Türk, Knoll, Petrik, Sarica, Seitz, Skolarikos, Straub.
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