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European Association of Urology

EAU Guidelines – Editor's choice

European Association of Urology Guidelines on the Diagnosis and Treatment of Urolithiasis

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Abstract

Background and objective: The European Association of Urology urolithiasis guidelines provide evidence-based recommendations for the diagnosis and treatment of urinary stone disease. Given the complexity and variability of stone formation, individualised patient management is emphasised.

Methods: The guidelines incorporate evidence from the latest research and focus on risk assessment, imaging techniques, pharmacological management, and surgical interventions. A research librarian conducted literature searches for urolithiasis in the Cochrane Library, Medline, and Embase databases via Dialog-Datastar. The strength of recommendations is also rated.

Key findings and limitations: Diagnosis relies on a combination of clinical history, biochemical evaluation, and imaging, with ultrasound as the first-line modality and low-dose computed tomography as the gold standard for precise stone assessment. Stone composition and burden influence treatment decisions with algorithms primarily based on stone size, location, and composition. Nonsteroidal anti-inflammatory drugs are recommended for first-line pain management, with opioids reserved as a secondary option. Medical expulsive therapy with α-blockers may be considered for selected patients with ureteral stones. Extracorporeal shockwave lithotripsy, ureteroscopy, and percutaneous nephrolithotomy remain the primary intervention modalities, with selection based on stone characteristics and patient factors. Advances in multiplanar imaging have improved assessment of the stone burden, although further research is needed to refine predictive models. Genetic testing is recommended for high-risk patients to guide personalised treatment.

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Conclusions and clinical implications: The guidelines provide a framework for clinical decision-making while acknowledging the need for continued advances in urolithiasis.

1. Introduction

Urinary stones can cause severe pain and complications and may recur, with an impact on the patient's the quality of life, so prompt diagnosis and effective management for prevention and treatment are required [1–3].

The European Association of Urology (EAU) guidelines on urolithiasis provide evidence-based recommendations for the diagnosis and management of urinary stones. Topics covered include stone classification, treatment options, and risk assessment with consideration of patient-specific factors. Emphasising the latest research, the aim of the recommendations is to optimise patient outcomes via conservative management, pharmacological therapy, or surgical intervention when necessary.

2. Methods

A research librarian conducted literature searches for urolithiasis up to August 2024 using the Cochrane Library, Medline, and Embase databases via Dialog-Datastar. Controlled terminology (MeSH, Emtree) and free text were used to ensure search sensitivity. The focus was on level 1 evidence (systematic reviews and meta-analyses of randomised controlled trials [RCTs]). If sufficient data were found, lower-level studies were excluded. Evidence levels followed the Oxford Centre for Evidence-based Medicine standards (https://www.cebm.net).

The EAU guideline panel prioritised key clinical decisions according to the balance of benefits and risks, evidence quality, and patient preferences. The strength of recommendations [4] was determined according to:

1. Evidence quality supporting the recommendation.
2. Effect magnitude (individual or combined).
3. Result certainty (precision, consistency, heterogeneity).
4. Balance of desirable versus undesirable outcomes.
5. Impact of patient values and preferences.

Recommendations are categorised as:

- Strong recommendation: high evidence quality, clear benefit-harm balance, and alignment of patient preferences.
- Weak recommendation: lower evidence quality, uncertain benefit-harm balance, or variable patient preferences.

3. Results

3.1. Prevalence, aetiology, and risk of recurrence

3.1.1. Overview

Urinary stone incidence varies by geography, climate, ethnicity, diet, and genetics, with prevalence ranging from 1% to 20% [5]. High-income countries such as Sweden, Canada, and the USA have rates exceeding 10%, with a 37% increase over 20 yr [6,7]. There is emerging evidence linking nephrolithiasis to the risk of chronic kidney disease (CKD) [8]. Stones can be stratified into those caused by infections, noninfectious factors, genetic defects [9], or adverse drug effects (drug stones), as listed in Table 1.

3.1.2. Stone composition

The most clinically relevant substances and the mineral components of different stone compositions are listed in Supplementary Table 1.

3.1.3. Risk groups for stone formation

Assessment of the risk of stone formation is crucial for treatment (Table 2). The following are key factors.

- Stone history: recurrence, regrowth, and past surgeries. Approximately 50% of recurrent stone-formers experience only one recurrence, while 10% have highly recurrent disease [7,10].
- Recurrence rate: among first-time stone-formers, the recurrence rate within 5 yr is 26% [11].
- Stone type and severity: the type of stone and its severity determine low- versus high-risk status (Table 2) [1].
- Holistic evaluation: all risk assessments should also consider CKD, end-stage kidney disease (ESKD), and metabolic bone disorder (MBD; Table 2) [12].

Stone-related risks arise from obstruction, infection, genetic conditions, metabolic disorders, and urological treatments, all of which may impact renal function [12].

Table 1 Stones classified by aetiology

Noninfection stones
• Calcium oxalate
• Calcium phosphate
• Uric acid
• Ammonium urate [a]
Infection stones
• Magnesium ammonium phosphate
• Highly carbonated apatite
• Ammonium urate
Genetic causes
• Cystine
• Xanthine
• 2,8-Dihydroxyadenine
Drug stones

[a] In children in developing countries; in patients with anorexia or laxative abuse.

Table 2 Risk factors for stone recurrence, CDK/ESRD in stone-formers, CDK and renal stones, and MBD and calcium renal stones

High-risk stone-formers	Risk factors for CDK/ESRD in stone-formers
General factors	
• Early onset of urolithiasis (especially children and teenagers)	• Female sex
• Familial stone formation	• Overweight
• Recurrent stone-formers	• Frequent urinary tract infections
• Short time since last stone episode	• Struvite stones
• Brushite-containing stones ($CaHPO_4{\cdot}2H_2O$)	• Acquired single kidney
• Uric acid and urate-containing stones	• Neurogenic bladder
• Infection stones	• Previous obstructive nephropathy
• Solitary kidney (the kidney itself does not particularly increase the risk of stone formation, but prevention of stone recurrence is of crucial importance to avoid acute renal failure)	• Ileal conduit
• CKD	
Diseases associated with stone formation	**Risk factors for CDK and renal stones**
	Possible risk of CKD
• Hyperparathyroidism	• Xanthine stones
• Metabolic syndrome, MBD	• Indinavir stones
• Nephrocalcinosis, polycystic kidney disease	• Distal renal tubular acidosis (incomplete)
• Gastrointestinal diseases (ie, enteric hyperoxaluria due to jejunoileal bypass, intestinal resection, Crohn's disease, malabsorptive conditions, urinary diversion, exocrine pancreatic insufficiency, and bariatric surgery)	• Primary hyperparathyroidism
• Elevated levels of vitamin D	• Eating disorders and laxative abuse
• Sarcoidosis	• Medullary sponge kidney
• Spinal cord injury, neurogenic bladder	
Genetically determined stone formation	Moderate risk of CKD
• Cystinuria (types A, B, and AB)	• Brushite stones
• Primary hyperoxaluria	• 2,8-Dihydroxyadenine stones
• Renal tubular acidosis type I	• Sarcoidosis
• 2,8-Dihydroxyadeninuria	• Pyeloureteral or ureteral strictures
• Xanthinuria	
• Lesch-Nyhan syndrome	
• Cystic fibrosis	
Drug-induced stone formation	High risk of CKD
• **Active compounds crystallising in urine**	• Cystine stones
o Allopurinol/oxypurinol	o Struvite stones
o Amoxicillin/ampicillin	• Stones in a single kidney
o Ceftriaxone	• Distal renal tubular acidosis (complete)
o Quinolones	• Secondary hyperoxaluria (bariatric surgery, inflammatory bowel disease, bowel resection and malabsorptive syndromes)
o Ephedrine	
o Indinavir and other HIV-protease inhibitors	• Other forms of nephrocalcinosis (often associated with genetic conditions with hypercalciuria)
o Magnesium trisilicate	
o Sulfonamides	• Anatomical abnormalities of the kidney and urinary tract (eg, horseshoe kidney, ureterocele and vesicoureteral reflux)
o Triamterene	
	• Neurological bladder
• **Substance impairing urine composition**	
o Acetazolamide	
o Aluminium magnesium hydroxide	
o Ascorbic acid	
o Calcium	
o Laxatives	
o Losartan	
o Methoxyflurane	
o Orlistat	
o Vitamin D	
o Topiramate	
o Zonisamide	
Anatomic abnormalities associated with stone formation	Very high risk of CKD
• Medullary sponge kidney (tubular ectasia)	• Primary hyperoxaluria
• Ureteropelvic junction obstruction	• Autosomal dominant polycystic kidney
• Calyceal diverticulum	
• Calyceal cyst	
• Ureteral stricture	
• Vesicoureterorenal reflux	
• Horseshoe kidney	
• Ureterocele	
Environmental and professional factors	**Risk factors for MBD and calcium renal stones**
• High ambient temperatures	• Distal renal tubular acidosis (complete or incomplete)
• Chronic, lead, and cadmium exposure	• Medullary sponge kidney
	• Primary hyperparathyroidism
	• Malabsorptive syndromes
	• Fasting hypercalciuria
	• Genetic disorders

CKD = chronic kidney disease; ESRD = end-stage renal disease; MBD = metabolic bone disease.

3.1.4. Genetic factors and testing

3.1.4.1. Overview. Genetic factors play a significant role in kidney stone disease (KSD), with estimated heritability of ~45% [13,14]. Monogenic forms are seen in 12–21% of children/young adults [15,16] and 1–11% of adults [16,17], and identification can aid in targeted management [17]. However, diagnostic criteria vary, and studies often focus on selected populations. The only study comparing 24-h urine findings revealed no differences except for higher urinary cystine among monogenic KSD cases [17].

3.1.4.2. Genetic testing. Next-generation sequencing to identify pathogenic gene variants (Table 3) should be considered for the following cases:

- Children and adults aged ≤25 yr;
- Adults aged >25 yr with a suspected inherited or metabolic disorders; and
- Patients with recurrent stones (≥2 episodes), bilateral disease, or a strong family history [18].

Testing should be combined with metabolic evaluations, and counselling before any test is essential. If a genetic diagnosis is confirmed, family screening should be offered.

3.2. Classification of stones

Urinary stones can be classified according to their size, location, X-ray characteristics, aetiology of formation, composition, and risk of recurrence [1,7].

3.2.1. Stone size

Stone size can be reported in terms of a single, two, or three dimensions. The guidelines still use linear measurement of the cumulative stone diameter to stratify stones as <5 mm, 5–10 mm, 10–20 mm, and >20 mm for use in treatment algorithms.

3.2.2. Stone location

Stones can be classified according to their anatomic position: upper, middle, or lower calyx; renal pelvis; upper, middle, or distal ureter; and urinary bladder.

3.2.3. X-ray characteristics

Stones can be classified according to their appearance on plain X-ray (kidney-ureter-bladder [KUB] radiography; Supplementary Table 2), which varies by mineral composition [19]. Non–contrast-enhanced computed tomography (CT) can be used to classify stones according to their density, inner structure, and composition, which can affect treatment decisions [19,20].

3.3. Diagnostic evaluation

Standard evaluation includes a detailed medical history and physical examination. Immediate evaluation is indicated in patients with a solitary kidney or fever and when there is doubt regarding a diagnosis of renal colic (strong recommendation).

Table 3 Known pathogenic genes

Gene	Associated conditions	Recommended treatment
SLC7A9 *SLC3A1*	Cystinuria, cystine stones, calcium-containing stones	Urinary alkalisation; thiol-binding drugs; aggressive urinary dilution
CYP24A1	Idiopathic infantile hypercalcaemia, calcium-containing stones	Avoidance of excess vitamin D; inhibition of vitamin D synthesis (eg, fluconazole)
AGXT *GRHPR* *HOGA1*	Primary hyperoxaluria, calcium oxalate stones	Pyridoxine or lumasiran for *AGXT* mutations. potassium citrate, magnesium oxide and/or orthophosphate; aggressive urine dilution, limit oxalate intake
CLDN16 *CLDN19*	Familial hypomagnesaemia, calcium-containing stones	Magnesium replacement; caution with vitamin D replacement; assess for ocular phenotypes with *CLDN19* variants
CASR	Autosomal dominant hypocalcaemia, calcium-containing stones	Avoid overzealous correction of hypocalcaemia
SLC34A1 *SLC34A3* *PHEX*	Hypophosphataemic rickets, calcium-containing stones	Screen for osteomalacia; phosphate replacement without vitamin D
CLCN5 *OCRL*	Dent disease, calcium-containing stones	Screen for osteomalacia; vitamin D; phosphate and bicarbonate replacement if needed; thiazide diuretics
SLC22A12 *SLC2A9*	Renal uric acid wasting, uric acid stones	Urinary alkalinization; allopurinol or febuxostat
BSND *CASR* *CLCN5* *CLCNKB* *KCNJ1* *SLC12A1*	Bartter syndrome, calcium-containing stones	NSAIDs, aldosterone antagonists, electrolyte replacement as required
HNF4A	Fanconi syndrome, nephrocalcinosis	Refer to nephrology
XDH *MOCOS*	Xanthinuria, xanthine stones	Low-purine diet
ATPV0A4 *ATP6V1B1* *CA2* *SLC4A1* *WDR72*	Renal tubular acidosis, calcium-containing stones	Sodium bicarbonate or alkaline citrate; hearing screen; assessment for osteomalacia/ osteopetrosis
APRT	Adenine phosphoribosyltransferase deficiency, 2,8 dihyroxyadenine stones	Allopurinol or febuxostat

3.3.1. Diagnostic imaging

Ultrasound (US) is the primary diagnostic tool but should not delay emergency care (strong recommendation). US sensitivity is 45%, with specificity of 94% for ureteral and 88% for renal stones [21,22]. KUB radiography (44–77% sensitivity [23]) helps in differentiating between radioopaque and radiolucent stone types and aids in follow-up [24].

Non–contrast-enhanced CT is the standard modality for acute flank pain after US (strong recommendation) to assess stone location, burden, density, and anatomy [25–27]. Low-dose CT reduces the risks associated with radiation while maintaining high diagnostic accuracy (93.1% sensitivity, 96.6% specificity) [28,29].

3.3.2. Diagnostics related to metabolic conditions

Besides imaging, each emergency patient with urolithiasis requires a biochemical urine work-up (dipstick of a urine sample) and blood tests (creatinine, uric acid, ionised calcium sodium, potassium, blood cell count, C-reactive protein [CRP]). At this point, no distinction is made between high and low risk for stone formation.

The biochemical work-up is similar for all stone patients (Supplementary Table 3). However, if no intervention is planned, measurement of sodium, potassium, CRP, and blood coagulation time can be omitted. Only patients at high risk of stone recurrence should undergo a more specific analytical program [1]. Stone analysis should be performed for all first-time stone-formers, if not all stone-formers (Supplementary Table 3).

3.3.3. Diagnosis in special groups and conditions

For imaging in pregnant women, the guideline panel strongly recommends the use of US, magnetic resonance imaging, and low-dose CT as first-, second-, and last-line options, respectively [1].

When a stone is suspected in a child, US is also strongly recommended as first-line imaging, followed by KUB or low-dose non–contrast-enhanced CT if US will not provide the information required [1].

3.4. Disease management

3.4.1. Individualised treatment of urolithiasis

Treatment is tailored to each patient according to stone size, number, location, and composition. Additional factors include stone shape, volume, mobility, and hardness, as well as the anatomy and compliance of the pelvic calyceal system. The development of comprehensive treatment algorithms is challenging because of disease variability and limited comparative clinical studies.

3.4.2. Renal colic

Nonsteroidal anti-inflammatory drugs (NSAIDs; diclofenac, ibuprofen, metamizole) are the first-line treatment for renal colic [30]. NSAIDs reduce the need for additional analgesia in comparison to opioids [31] but may increase cardiovascular and gastrointestinal risks, so the lowest effective dose should be used. NSAIDs may also impact renal function in patients with low glomerular filtration rate [32,33].

Opioids are recommended as second-choice analgesics. Opioids, particularly pethidine, are associated with a high rate of vomiting in comparison to NSAIDs and a greater likelihood of further analgesia being needed [30,34]. If an opioid is required, an agent other than pethidine is recommended, such as hydromorphine, pentazocine, or tramadol.

For ureteral stones that are likely to pass spontaneously, NSAIDs (eg, diclofenac 100–150 mg/d for 3–10 d) can reduce inflammation and recurrence of pain [35,36]. If pain persists despite medication, drainage or stone removal is necessary [37].

3.4.3. Management of sepsis and/or anuria in an obstructed kidney

In cases of sepsis and/or anuria in an obstructed kidney, urgent decompression of the system via either percutaneous nephrostomy or ureteral stenting is strongly recommended [2]. Definitive treatment of the stone should be delayed until sepsis is resolved (strong recommendation). Urine should be collected for antibiogram testing before and after decompression (strong recommendation). Antibiotics should be given immediately, and the regimen should be re-evaluated following antibiogram findings (strong recommendation) [38–40]. Intensive care might become necessary.

3.4.4. Medical expulsive therapy

Medical expulsive therapy (MET; α-blockers for an off-label class effect) seems to be efficacious for the treatment of ureteral stones in patients amenable to conservative management. The greatest benefit might be for those with stones >5 mm in the (distal) ureter (strong recommendation) [41].

3.4.5. Chemolysis

Percutaneous irrigation chemolysis is rarely used [42], while oral chemolysis is strongly recommended for uric acid stones. Alkalisation with citrate or sodium bicarbonate (pH 7.0–7.2) can dissolve stones. Patients should monitor their urine pH and adjust the medication accordingly. Studies show a success rate of 80.5%, with 15.7% of patients needing further intervention [43].

3.4.6. General recommendations and precautions for stone removal

3.4.6.1. Antibiotic therapy. Before stone treatment, urine microscopy and culture results should be obtained to exclude or treat urinary tract infection (UTI) before stone removal (strong recommendation). Perioperative antibiotic prophylaxis should be offered to all patients undergoing endourological treatment (strong recommendation).

Administration of a single dose of prophylactic antibiotic before ureteroscopy (URS) was sufficient [44–46]. According to three meta-analyses of pooled data from a small series of varying quality, an extended course of preoperative antibiotic prophylaxis before percutaneous nephrolithotomy (PCNL) significantly reduced postoperative sepsis and fever among patients with an a priori higher risk of infection in comparison to a single dose before anaesthesia [47–49]. In studies that did not specify the risk for the patient population, a single dose of antibiotic prophylaxis administered at induction was equivalent to an extended preoperative course [49,50].

As national and regional antibiotic resistance patterns can differ significantly, the choice of antibiotic prophylaxis should be tailored to institutional or regional antimicrobial susceptibility [46].

3.4.6.2. Antithrombotic therapy and stone treatment. Patients with a bleeding disorder and those receiving antithrombotic therapy should be referred to an internist for appropriate therapeutic measures before deciding on stone management.

Cystoscopy, flexible cystoscopy, ureteral catheterisation, extraction of a ureteral stent, and URS are classified as procedures with a low risk of bleeding. On the contrary, extracorporeal shockwave lithotripsy (ESWL), percutaneous nephrostomy, and PCNL are classified as procedures with a high risk of bleeding [51–54].

Temporary discontinuation or bridging of antithrombotic therapy in high-risk patients, in consultation with the internist, is strongly recommended.

Retrograde (flexible) URS is the preferred intervention if stone removal is essential and antithrombotic therapy cannot be discontinued, as URS is associated with lower morbidity (strong recommendation). Supplementary Table 4 shows the suggested strategy for antithrombotic therapy in stone treatment.

3.4.7. ESWL

3.4.7.1. Indications and success rates. ESWL success depends on the lithotripter efficacy and factors that include stone size, location, and composition, patient habitus, and procedure quality. These parameters influence retreatment rates and outcomes (Table 4).

Table 4 Summary of recommendations for the treatment of urinary stones

Recommendation	Strength rating
General	
Consider the stone composition before deciding on the method for removal, which should be based on the patient's history, stone analysis, or HU on unenhanced CT.	Strong
Attempt to dissolve radiolucent stones.	Strong
Extracorporeal SWL	
Ensure correct use of the coupling agent, as 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 before SWL in cases with infected stones or bacteriuria.	Strong
Ureteroscopy	
Use Ho:YAG or thulium fibre 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
Endourology techniques for renal stone removal	
Perform preprocedural CT imaging, including contrast medium when indicated, or a retrograde study when starting the procedure to assess the stone extent and the anatomy of the collecting system to ensure safe access to the renal stone.	Strong
Perform a tubeless (no nephrostomy tube) or totally tubeless (no nephrostomy tube or ureteral stent) PCNL procedure in uncomplicated cases.	Strong
Obtain a urine culture or perform urinary microscopy before any treatment is planned.	Strong
Exclude or treat urinary tract infection before stone removal.	Strong
Offer perioperative antibiotic prophylaxis to all patients undergoing endourological treatment.	Strong
Antithrombotic therapy	
Offer active surveillance of an asymptomatic calyceal stone to patients at high risk of thrombotic complications.	Weak
Decide on temporary discontinuation or bridging of antithrombotic therapy in high-risk patients, in consultation with the internist.	Strong
Retrograde (flexible) URS is the preferred intervention if stone removal is essential and antithrombotic therapy cannot be discontinued, as this approach is associated with less morbidity.	Strong
Active removal of ureteral stones	
If active removal is not indicated (Section 3.4.10.3) in patients with newly diagnosed small ureteral stones, observe the patient initially with periodic evaluation.	Strong
Offer α-blockers as medical expulsive therapy as one of the treatment options for (distal) ureteral stones >5 mm.	Strong
Inform patients that URS has a better chance of achieving stone-free status in a single procedure.	Strong
Inform patients that URS has a higher complication rate in comparison to SWL.	Strong
Use URS as first-line therapy for ureteral (and renal) stones in cases of severe obesity.	Strong
Active removal of renal stones	
Offer active treatment for renal stones in cases with stone growth, de novo obstruction, associated infection, and acute and/or chronic pain.	Weak
Evaluate stone composition before deciding on the method for removal, which should be based on the patient's history, stone analysis, or HU on unenhanced CT.	Strong
Perform PCNL as first-line treatment for larger stones (>2 cm).	Strong
Treat larger stones (>2 cm) with flexible URS or SWL in cases in which PCNL is not an option. However, there is a higher risk that a follow-up procedure and placement of a ureteral stent may be needed in such cases.	Strong
Perform PCNL or retrograde intrarenal surgery for lower-pole stones, even for stones >1 cm, as the efficacy of SWL is limited (depending on favourable and unfavourable factors for SWL).	Strong

CT = computed tomography; HU = Hounsfield units; PCNL = percutaneous nephrolithotomy; SWL = shockwave lithotripsy; URS = ureteroscopy; YAG = yttrium-aluminium-garnet.

3.4.7.2. ESWL contraindications. ESWL is contraindicated in cases involving pregnancy [55], bleeding disorders [56], uncontrolled UTI, severe obesity, skeletal malformations, an arterial aneurysm near the stone [57], or anatomic obstructions distal to the stone.

3.4.7.3. Best clinical practice. The following points are relevant in best clinical practice for ESWL [58]:

- Routine stenting before ESWL does not improve stone-free rates but may reduce steinstrasse.
- In patients with a pacemaker or defibrillator, ESWL is feasible with technical precautions; newer lithotripters may eliminate the need for reprogramming of defibrillators.
- Shockwave parameters: decreasing the frequency (from 120 to 60–90/min) improves stone-free rates and reduces tissue damage. There is no consensus on the maximum number of shockwaves per session. Stepwise energy ramping minimises renal injury.
- Coupling technique: proper acoustic coupling between the treatment head and the skin is crucial, as air pockets can deflect shockwaves.
- Operator experience: better outcomes are observed when ESWL is performed by experienced clinicians with precise imaging control.
- Adjunct therapies: MET, mechanical percussion, and diuretics can enhance stone passage and reduce analgesic needs.

3.4.7.4. ESWL complications. ESWL has fewer complications than PCNL or URS. A meta-analysis revealed rates of 18.43% for Clavien grade I–II and 2.48% for Clavien grade III–IV complications [59]. Complications related to stone fragments include steinstrasse (4%), macroscopic haematuria (17.2%), pain (12.1%), regrowth of residual fragments (21–59%), a need for auxiliary procedures (6–9%), and renal colic (2–4%). Infectious complications include bacteriuria in cases of non-infection stones (7.7–23%) and sepsis (0.15%). Tissue complications include renal (symptomatic haematoma 0.21%, asymptomatic haematoma 1.2%) and cardiovascular (dysrhythmias 11–29%) effects.

The link between SWL and hypertension/diabetes remains unclear, with no conclusive evidence of long-term adverse effects.

3.4.8. Retrograde and antegrade URS

3.4.8.1. Overview. Standard rigid ureteroscopes have a tip diameter of <8 F and can access the entire ureter, but flexible URS is increasingly favoured because of technical advances [60]. Percutaneous antegrade URS is an option for large (>15 mm), impacted proximal ureteral stones in dilated systems or when retrograde access is not feasible [61] (Table 4).

3.4.8.2. URS contraindications. URS has no specific contraindications aside from general anaesthesia risks and untreated UTIs.

3.4.8.3. Best clinical practice. The following points are relevant in best clinical practice for URS [58]:

- Anaesthesia and instrumentation: Most procedures use general anaesthesia; smaller-calibre ureteroscopes are associated with better outcomes. Disposable ureteroscopes are as effective as reusable ones.
- Safety measures: fluoroscopy should be available and placement of a safety wire is recommended. If access is difficult, a double-J stent for 7–14 d can facilitate subsequent URS.
- The operative time should remain <90 min to minimise complications.
- Ureteral access sheaths improve vision, reduce intrarenal pressure, and facilitate access but may risk ureteral damage, particularly with larger sheaths.
- Stone removal via lithotripsy:
  - Complete stone removal is the goal. "Dust and go" should be limited to large renal stones.
  - Ho:YAG laser is the gold standard; high-power settings reduce the lasering time but have no proven clinical advantage.
  - Thulium fibre laser offers comparable efficacy.
  - MET after laser lithotripsy aids stone passage and reduces colic.
- Stenting:
  - Routine prestenting is not required but may improve treatment outcomes for renal stones.
  - Routine post-URS stenting is unnecessary after uncomplicated procedures and may increase morbidity.
  - Stenting is advised in cases with trauma, residual fragments, bleeding, perforation, UTI, or pregnancy.
  - α-Blockers improve stent tolerability.

3.4.8.4. URS complications. The overall rate of complications after URS is 4–25%, most of which are minor [62]. Postoperative urosepsis can occur in up to 5% of cases. Rare but serious complications include ureteral avulsion and strictures (<1%). Risk factors include a long procedure time, preoperative infection, and comorbidities. Prevention measures include antibiotic prophylaxis, steps to reduce the intrarenal pressure [63], and limiting the stent time.

3.4.9. PCNL

3.4.9.1. Overview. PCNL remains the standard treatment for large renal stones (Table 4). Standard access tracts are 24–30 F, but smaller sheaths (<18 F) are increasingly being used in adults [64,65].

3.4.9.2. PCNL contraindications. Patients on anticoagulants require careful monitoring if PCNL is planned. Other PCNL contraindications include untreated UTI, tumour in the access tract, suspected malignant kidney tumours, and pregnancy.

3.4.9.3. Best clinical practice. The following points are relevant in best clinical practice for PCNL [58]:

- Lithotripsy methods: ultrasonic, pneumatic, and combined systems are common for rigid nephroscopy; lasers are increasingly used for flexible instruments.
- Preoperative imaging: US or CT can help in identifying interposed organs (eg, liver, spleen, bowel).

- Positioning: the prone and supine positions are equally safe. A supine position allows simultaneous retrograde access.
- Puncture guidance: fluoroscopy is standard for puncture guidance, but US reduces radiation exposure and has lower complication rates. Flexible URS can enhance puncture accuracy.
- Dilatation: options for dilatation include metallic telescopic, single-step, and balloon dilators. Single-step dilation may shorten the operative time and reduce complications.
- Instrument choice: mini-PCNL (12–22 F) and standard PCNL (>22 F) provide similar stone-free rates. Mini-PCNL reduces blood loss, transfusion rates, and length of hospital stay without significant differences in complications. Suction during PCNL can reduce the intrarenal pressure and improve outcomes.
- Placement of a nephrostomy tube or double-J stent for postoperative drainage depends on factors that include residual stones, bleeding, urine leakage, or a risk of infection.
- Small-bore nephrostomy tubes reduce pain.
- Tubeless PCNL (no nephrostomy tube) reduces pain and the length of hospital stay.
- Totally tubeless PCNL (no nephrostomy or stent) is effective in uncomplicated cases.
- Double-J stents allow shorter hospital stays but may slightly impact quality of life.

3.4.9.4. PCNL complications. A review of 12 000 patients revealed fever (10.8%), transfusion (7%), thoracic complications (1.5%), sepsis (0.5%), organ injury (0.4%), embolisation (0.4%), urinoma (0.2%), and mortality (0.05%) as complications of PCNL [66].

3.4.10. Specific stone management of ureteral stones

3.4.10.1. Conservative treatment. Spontaneous stone passage varies by size and location, with reported rates of 49–52% for upper, 58–70% for mid, and 68–83% for distal ureteral stones. Stones <5 mm pass in 75% of cases, in comparison to 62% of stones ≥5 mm, typically within 17 d (range 6–29) [67,68].

The passage rate is 89% for distal stones <5 mm and 75% for upper ureteral stones <5 mm [67]. The likelihood of stone passage decreases with increasing stone size.

3.4.10.2. MET. MET is an option for informed patients when active removal is not required. MET should be stopped if complications arise (infection, refractory pain, or a decline in renal function). For uric acid stones in the distal ureter, alkalisation with tamsulosin improves passage rates.

3.4.10.3. Indications for stone removal. Stone removal is required in the following cases [69]:

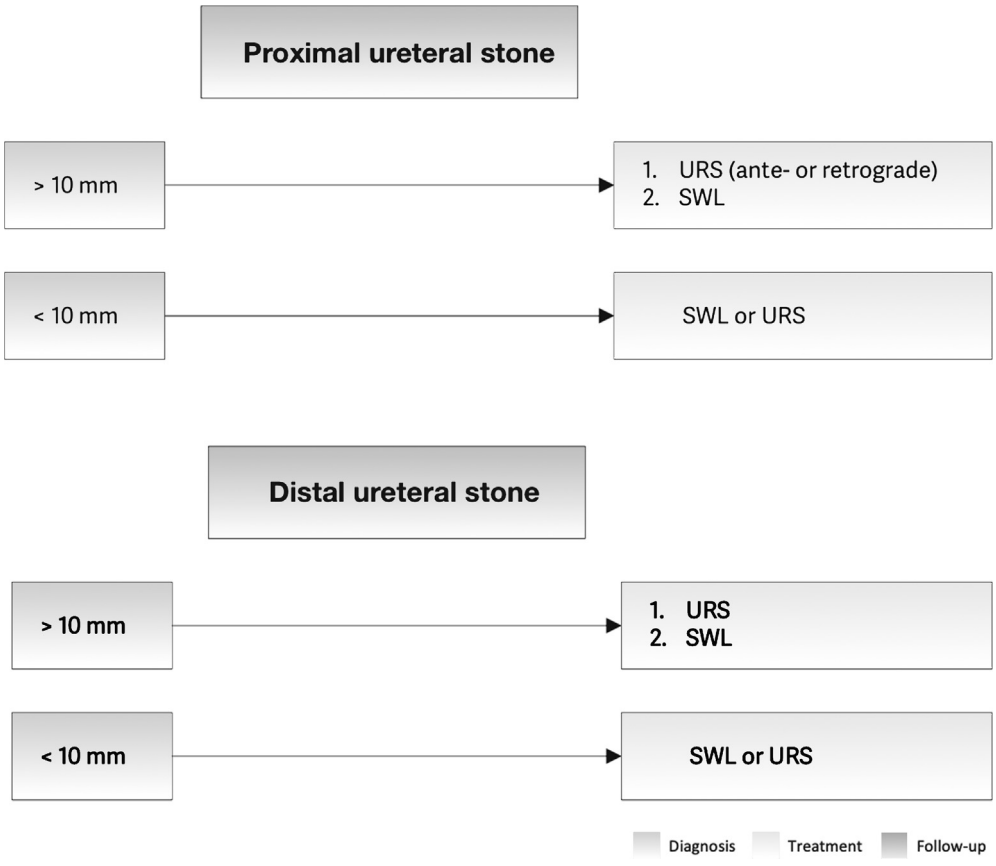

Fig. 1 – Treatment algorithm for ureteral stones if stone removal is indicated. SWL = shockwave lithotripsy; URS = ureteroscopy.

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

3.4.10.4. Selection of the procedure for removal of ureteral stones. Fig. 1 shows the treatment algorithm for ureteral stones when stone removal is indicated.

3.4.11. Specific management of renal stones

3.4.11.1. Observation. The natural history of small nonobstructing renal stones is unclear, and follow-up guidelines remain undefined. An RCT found higher relapse rates in untreated patients. Spontaneous passage occurs in 3–29% of cases, while symptoms develop in 7–77%. Stone growth (5–66%) and the need for surgery (7–26%) vary [70,71].

3.4.11.2. Indications for removal of renal stones. Renal stones should be removed if there is:

- Stone growth;
- High risk of stone formation;
- Obstruction;
- Infection;
- Symptoms (pain, haematuria);
- Patient preference or comorbidities; and
- Social factors (eg, profession, travel).

3.4.11.3. Selection of procedure for active removal of renal stones. Fig. 2 shows the treatment algorithm for renal stones when active treatment is indicated.

3.5. Radiation exposure and protection during endourology

Radiation protection in endourology is crucial to minimise exposure. The use of low-dose imaging, shielding, and optimised techniques helps in ensuring patient and staff safety. Supplementary Table 5 lists radiation protection measures for endourology procedures.

4. Discussion

This paper presents the EAU clinical guidelines on urolithiasis. The guidelines are based on the highest level of clinical evidence available for each topic addressed. Recommenda-

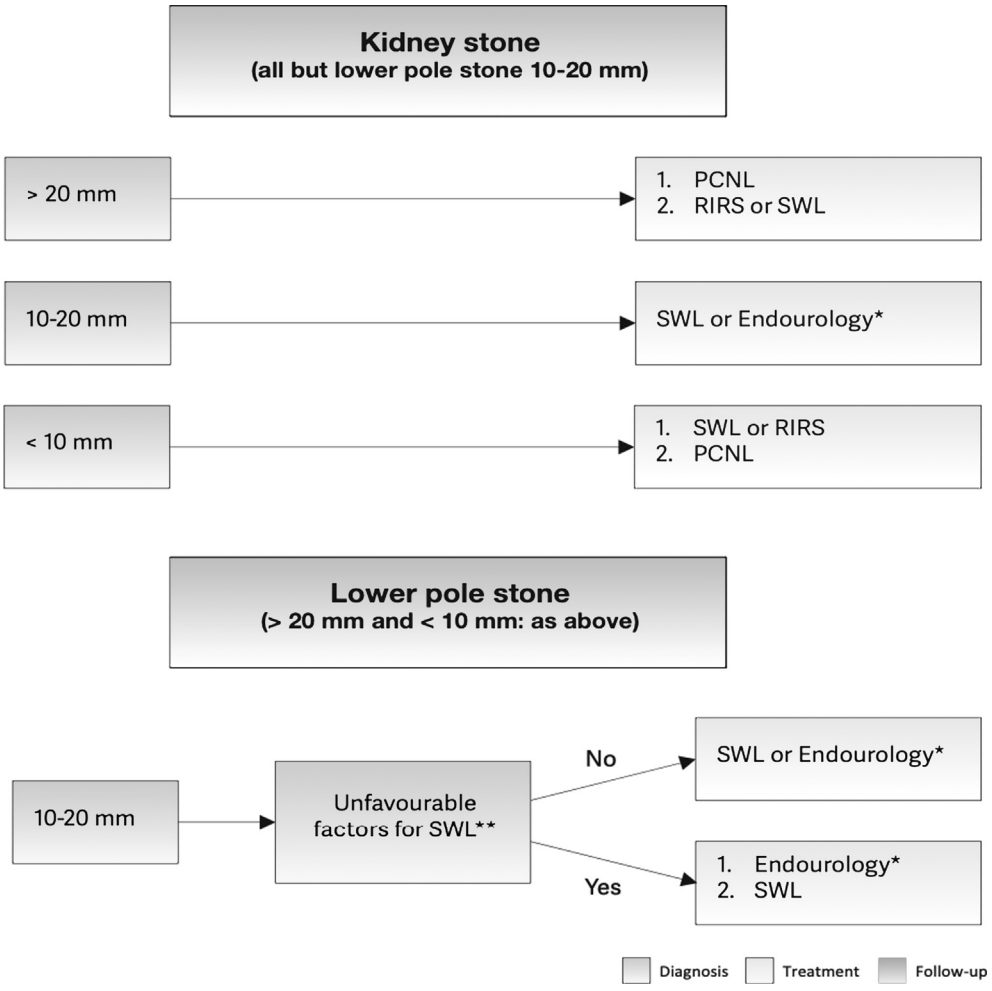

Fig. 2 – Treatment algorithm for renal stones if and when active treatment is indicated. PCNL = percutaneous nephrolithotomy; RIRS = retrograde intrarenal surgery; SWL = shockwave lithotripsy; URS = ureteroscopy. * The term "endourology" encompasses all PCNL and URS interventions.

tions are provided according to the level of evidence, with additional refinement using the GRADE methodology [72].

The literature on urolithiasis is highly diverse, primarily because of the variability in patient presentation. Categorisation of urolithiasis patients to establish standardised diagnostic and treatment protocols remains a significant challenge. Therefore, the guidelines panel emphasises that individualised diagnosis and treatment are fundamental to effective management.

A comprehensive patient history is essential to identify risk factors predisposing individuals to recurrence of urolithiasis after definitive treatment. In addition, as urolithiasis is associated with CKD and end-stage renal disease, identification of factors linking urolithiasis to renal impairment is crucial. Genetic testing should also be considered for specific patient groups [18].

Appropriate radiological imaging, combined with stone analysis when feasible, plays a key role in determining indications for either conservative or invasive treatment. Current treatment algorithms are based on stone location, maximum linear size, and composition.

CT has become the gold standard for diagnosis and treatment planning, and allows measurement of the stone burden in multiple dimensions. Consequently, research on the predictive value of multiplanar measurements for interventional outcomes has increased. Multiplanar measurements intuitively provide a more accurate representation of the stone burden and may provide better predictions of stone-free rates after intervention. However, studies evaluating the predictive value of multiplanar versus single-plane measurements have yielded inconsistent results.

A recent systematic review and meta-analysis by the guidelines panel [73] revealed that models incorporating multiplanar measurements of stone volume and surface area are statistically superior to those based solely on single-plane measurements in predicting stone-free status after intervention. Subanalysis showed no significant differences in predictive value for stone-free status following PCNL. However, stone volume was a significantly better predictor of stone-free status after ESWL and URS in comparison to linear size [73]. There was insufficient evidence for a meta-analysis of complication rates and operative time. Further research is needed to validate these findings before guideline modifications can be made to reflect new measurement practices.

5. Conclusions

The EAU urolithiasis guidelines emphasise individualised diagnosis and treatment, and include advanced imaging and evidence-based strategies. The recommendations highlight risk assessment, genetic testing, and optimised treatment algorithms to improve patient outcomes while acknowledging the need for further research to refine predictive models and intervention strategies.

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Study concept and design: Skolarikos, Geraghty, Somani, Tailly, Jung, Neisius, Petřík, Kamphuis, Davis, Lardas, Gambaro, Sayer, Lombardo, Tzelves.
Acquisition of data: Skolarikos.
Analysis and interpretation of data: Skolarikos.
Drafting of the manuscript: Skolarikos.
Critical revision of the manuscript for important intellectual content: Skolarikos, Geraghty, Somani, Tailly, Jung, Neisius, Petřík, Kamphuis, Davis, Lardas, Gambaro, Sayer, Lombardo, Tzelves.
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Supervision: Skolarikos, Geraghty, Somani, Tailly, Jung, Neisius, Petřík, Kamphuis, Davis, Lardas, Gambaro, Sayer, Lombardo, Tzelves.
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Supplementary data

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