GUIDELINES ON UROLITHIASIS

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C. Türk (chair), T. Knoll (vice-chair), A. Petrik, K. Sarica, C. Seitz, A. Skolarikos, M. Straub

Classification of stones

Urinary stones can be classified according to the following aspects: stone size, stone location, X-ray characteristics of stone, aetiology of stone formation, stone composition (mineralogy), and risk group for recurrent stone formation (Tables 1-3).

Table 1: X-ray characteristics

Radiopaque	Poor radiopaque	Radiolucent
Calcium oxalate dihydrate	Magnesium ammonium phosphate	Uric acid
Calcium oxalate monohydrate	Apatite	Ammonium urate
Calcium phosphates	Cystine	Xanthine
		2,8-dihydroxyadenine
		'Drug-stones'

Table 2: Stones classified according to their aetiology			
Non infection stones	**Infection stones**	**Genetic stones**	**Drug stones**
Calcium oxalates	Magnesium ammonium phosphate	Cystine	e.g. indinavir *(see extended document)*
Calcium phosphates	Carbonate apatite	Xanthine	
Uric acid	Ammonium urate	2,8-dihydroxy-adenine	

Table 3: Stones classified by their composition	
Chemical composition	**Mineral**
Calcium oxalate monohydrate	whewellite
Calcium-oxalate-dihydrate	wheddelite
Uric acid dihydrate	uricite
Ammonium urate	
Magnesium ammonium phosphate	struvite
Carbonate apatite (phosphate)	dahllite
Calcium hydrogenphosphate	brushite
Cystine	
Xanthine	
2,8-dihydroxyadenine	
'Drug stones'	

Risk groups for stone formation

The risk status of a stone former is of particular interest as it defines both probability of recurrence or (re)growth of stones and is imperative for pharmacological treatment.

Table 4: High risk stone formers
General factors
Early onset of urolithiasis in life (especially children and teenagers)
Familial stone formation
Brushite containing stones (calcium hydrogen phosphate; $CaHPO_4.2H_2O$)
Uric acid and urate containing stones
Infection stones
Solitary kidney (The solitary kidney itself does not present an increased risk of stone formation, but prevention of stone recurrence is more important)
Diseases associated with stone formation
Hyperparathyroidism
Nephrocalcinosis
Gastrointestinal diseases or disorders (e.g. jejuno-ileal bypass, intestinal resection, Crohn's disease, malabsorptive conditions, enteric hyperoxaluaria after urinary diversion and bariatric surgery)
Sarcoidosis
Genetically determined stone formation
Cystinuria (type A, B, AB)
Primary hyperoxaluria (PH)
Renal tubular acidosis (RTA) type I
2,8-dihydroxyadenine
Xanthinuria
Lesch-Nyhan-Syndrome
Cystic fibrosis
Drugs associated with stone formation (*see* Chapter 11 extended text)
Anatomical abnormalities associated with stone formation
Medullary sponge kidney (tubular ectasia)

UPJ obstruction
Calyceal diverticulum, calyceal cyst
Ureteral stricture
Vesico-uretero-renal reflux
Horseshoe kidney
Ureterocele

DIAGNOSIS

Diagnostic imaging

Standard evaluation of a patient includes taking a detailed medical history and physical examination. The clinical diagnosis should be supported by appropriate imaging.

Recommendation	LE	GR
With fever or solitary kidney, and when diagnosis is doubtful, immediate imaging is indicated.	4	A*

**Upgraded following panel consensus.*

If available, ultrasonography should be used as the primary diagnostic imaging tool although pain relief, or any other emergency measures should not be delayed by imaging assessments. KUB should not be performed if non-contrast enhanced computed tomography (NCCT) is considered, but KUB can differentiate between radiolucent and radiopaque stones and serve for comparison during follow-up.

Evaluation of patients with acute flank pain

Recommendation	LE	GR
NCCT should be used to confirm stone diagnosis in patients with acute flank pain, because it is superior to IVU.	1a	A

Some drug stones like indinavir stones are not detectable on NCCT.

Recommendation	LE	GR
A renal contrast study (enhanced CT or IVU) is indicated when planning treatment for renal stones.	3	A*

**Upgraded following panel consensus.*

Biochemical work-up

Each emergency patient with urolithiasis needs a succinct biochemical work-up of urine and blood besides imaging studies; no difference is made between high- and low-risk patients.

Recommendations: Basic analysis emergency stone patient	
Urine	**GR**
Urinary sediment/dipstick test out of spot urine sample for: red cells / white cells / nitrite / urine pH level by approximation.	A*
Urine culture or microscopy.	A
Blood	
Serum blood sample creatinine / uric acid / ionized calcium / sodium / potassium / CRP.	A*
Blood cell count.	A*
If intervention is likely or planned: Coagulation test (PTT and INR).	A*

**Upgraded following panel consensus.*

Examination of sodium, potassium, CRP, and blood coagulation time can be omitted in the non-emergency stone patient.

Patients at high risk for stone recurrences should undergo a

more specific analytical programme (*see* section on Metabolic Evaluation below).

Analysis of stone composition should be performed in all first-time stone formers (GR: A) and will need redoing if changes are expected. The preferred analytical procedures are:

- X-ray diffraction (XRD)
- Infrared spectroscopy (IRS)

Wet chemistry is generally deemed to be obsolete.

Acute treatment of a patient with renal colic

Pain relief is the first therapeutic step in patients with an acute stone episode.

Recommendations for pain relief during and prevention of recurrent renal colic	LE	GR
First choice: start with an NSAID, e.g. diclofenac*, indomethacin or ibuprofen.**	1b	A
Second choice: hydromorphine, pentazocine and tramadol.	4	C
Use α-blockers to reduce recurrent colic.	1a	A

GFR = glomerular filtration rate; NSAID = non-steroidal anti-inflammatory drug.
**Caution: Diclofenac sodium affects GFR in patients with reduced renal function, but not in patients with normal renal function (LE: 2a).*
*** Recommended to counteract recurrent pain after renal colic. (see extended document section 5.3)*

If analgesia cannot be achieved medically, drainage, using stenting or percutaneous nephrostomy, or stone removal, should be performed.

Management of sepsis in the obstructed kidney

The obstructed, infected kidney is a urological emergency.

Recommendations	LE	GR
For sepsis with obstructing stones, the collecting system should be urgently decompressed, using either percutaneous drainage or ureteral stenting.	1b	A
Definitive treatment of the stone should be delayed until sepsis is resolved.	1b	A

In exceptional cases, with severe sepsis and/or the formation of abscesses, an emergency nephrectomy may become necessary.

Recommendations - Further Measures	GR
Collect urine for antibiogram following decompression.	A*
Start antibiotics immediately thereafter (+ intensive care if necessary).	
Revisit antibiotic treatment regimen following antibiogram findings.	

** Upgraded based on panel consensus.*

Stone relief

When deciding between active stone removal and conservative treatment using MET, it is important to consider the individual circumstances of a patient that may affect treatment decisions.

Observation of ureteral stones

Recommendations	LE	GR
In patients with newly diagnosed ureteral stones < 10 mm, and if active stone removal is not indicated, observation with periodic evaluation is optional initial treatment.	1a	A
Such patients may be offered appropriate medical therapy to facilitate stone passage during observation*.		

**see also Section MET.*

Observation of kidney stones

It is still debatable whether kidney stones should be treated, or whether annual follow-up is sufficient for asymptomatic caliceal stones that have remained stable for 6 months.

Recommendations	GR
Kidney stones should be treated in case of growth, formation of de novo obstruction, associated infection, and acute and/or chronic pain.	A
Comorbidity and patient preference need to be taken into consideration when making treatment decisions.	C
If kidney stones are not treated, periodic evaluation is needed.	A

** Upgraded following panel consensus.*

Medical expulsive therapy (MET)

For patients with ureteral stones that are expected to pass spontaneously, NSAID tablets or suppositories and α-blockers may help to reduce inflammation and the risk of recurrent pain.

Recommendations for MET	LE	GR
For MET, α-blockers are recommended.		A
Patients should be informed about the attendant risks of MET, including associated drug side effects, and should be informed that it is administered as 'off-label'**.		A*
Patients, who elect for an attempt at spontaneous passage or MET, should have well-controlled pain, no clinical evidence of sepsis, and adequate renal functional reserve.		A
Patients should be followed to monitor stone position and to assess for hydronephrosis.	4	A*

**Upgraded following panel consensus.*

***MET using α-blockers in children and during pregnancy cannot be recommended due to the limited data in this specific population.*

Statements	LE
There is good evidence that MET accelerates spontaneous passage of ureteral stones and fragments generated with SWL limits pain.	1
No recommendation for the use of corticosteroids in combination with α-blockers in MET can be made, due to limited data.	1b

Chemolytic dissolution of stones

Oral or percutaneous irrigation chemolysis of stones can be a useful first-line therapy or an adjunct to SWL, PNL, URS, or open surgery to support elimination of residual fragments. However, its use as first-line therapy may take weeks to be effective.

Percutaneous irrigation chemolysis

Recommendations	GR
In percutaneous chemolysis, at least two nephrostomy catheters should be used to allow irrigation of the renal collecting system, while preventing chemolytic fluid draining into the bladder and reducing the risk of increased intrarenal pressure*.	A
Pressure- and flow-controlled systems should be used if available.	

* *Alternatively, one nephrostomy catheter with a JJ stent and bladder catheter can serve as a through-flow system preventing high pressure.*

Methods of percutaneous irrigation chemolysis

Percutaneous irrigation chemolysis is rarely used; it may be an option for infection stones (using 10% Hemiacidrin at a pH of 3,5 -4) and for uric acid and cystine stones (using THAM [Trihydroxymethylaminomethan], 0.3 or 0.6mol/L, pH 8.5-9.0).

For uric acid stones oral chemolysis is preferred.

Oral chemolysis

Oral chemolitholysis is efficient for uric acid calculi only. The urine pH should be adjusted to between 6.5 and 7.2.

Recommendations	GR
The dosage of alkalising medication must be modified by the patient according to the urine pH, which is a direct consequence of the alkalising medication.	A
Dipstick monitoring of urine pH by the patient is required at regular intervals during the day. Morning urine must be included.	A

Careful monitoring of radiolucent stones during/after therapy is imperative.	A
The physician should clearly inform the patient of the significance of compliance.	A

SWL

The success rate for SWL will depend on the efficacy of the lithotripter and on:

- size, location (ureteral, pelvic or calyceal), and composition (hardness) of the stones;
- patient's habitus;
- performance of SWL.

Contraindications of SWL

Contraindications to the use of SWL are few, but include:

- pregnancy;
- bleeding diatheses;
- uncontrolled urinary tract infections (UTIs);
- severe skeletal malformations and severe obesity, which prevent targeting of the stone;
- arterial aneurism in the vicinity of the stone;
- anatomical obstruction distal of the stone.

Stenting prior to SWL

Kidney stones

A JJ stent reduces the risk of renal colic and obstruction, but does not reduce formation of steinstrasse or infective complications.

Recommendation - stenting & SWL	LE	GR
Routine stenting is not recommended as part of SWL treatment of ureteral stones.	1b	A

Best clinical practice (best performance)

Pacemaker

Patients with a pacemaker can be treated with SWL, provided that appropriate technical precautions are taken; patients with implanted cardioverter defibrillators must be managed with special care (firing mode temporarily reprogrammed during SWL treatment). However, this might not be necessary with new-generation lithotripters.

Recommendation - Shock wave rate	LE	GR
The optimal shock wave frequency is 1.0 (to 1.5) Hz.	1a	A

Number of shock waves, energy setting and repeat treatment sessions

- The number of shock waves that can be delivered at each session depends on the type of lithotripter and shockwave power.
- Starting SWL on a lower energy setting with step-wise power (and SWL sequence) ramping prevents renal injury.
- Clinical experience has shown that repeat sessions are feasible (within 1 day for ureteral stones).

Procedural control

Results of treatment are operator dependent. Careful imaging control of localisation will contribute to outcome quality.

Pain control

Careful control of pain during treatment is necessary to limit pain-induced movements and excessive respiratory excursions.

Antibiotic prophylaxis

No standard prophylaxis prior to SWL is recommended.

Recommendation	LE	GR
In case of infected stones or bacteriuria, antibiotics should be given prior to SWL.	4	C

Medical expulsive therapy (MET) after SWL can expedite expulsion and enhance stone-free rates.

Percutaneous nephrolitholapaxy (PNL)

Recommendation	GR
Ultrasonic, ballistic and Ho:YAG devices are recommended for intracorporeal lithotripsy using rigid nephroscopes.	A*
When using flexible instruments, the Ho:YAG laser is currently the most effective device available.	

** Upgraded following panel consensus.*

Best clinical practice

Contraindications:

- all contraindications for general anaesthesia apply;
- untreated UTI;
- atypical bowel interposition;
- tumour in the presumptive access tract area;
- potential malignant kidney tumour;
- pregnancy.

Pre-operative recommendation - imaging	GR
Preprocedural imaging, including contrast medium where possible or retrograde study when starting the procedure, is mandatory to assess stone comprehensiveness, view the anatomy of the collecting system, and ensure safe access to the kidney stone.	A*

** Upgraded based on panel consensus.*

Positioning of the patient: prone or supine?

Traditionally, the patient is positioned prone for PNL, supine position is also possible, showing advantages in shorter operating time, the possibility of simultaneous retrograde transurethral manipulation, and easier anaesthesia. Disadvantages are limited manoeuvrability of instruments and the need of appropriate equipment.

Nephrostomy and stents after PNL

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

Ureterorenoscopy (URS)
(including retrograde access to renal collecting system)

Best clinical practice in URS

Before the procedure, the following information should be sought and actions taken (LE: 4):

- Patient history;
- physical examination (i.e. to detect anatomical and congenital abnormalities);
- thrombocyte aggregation inhibitors/anticoagulation (anti-platelet drugs) treatment should be discontinued. However, URS can be performed in patients with bleeding disorders, with only a moderate increase in complications;
- imaging.

Recommendation	GR
Short-term antibiotic prophylaxis should be administered.	A*

Contraindications

Apart from general considerations, e.g. with general anaesthesia or untreated UTIs, URS can be performed in all patients without any specific contraindications.

Access to the upper urinary tract

Most interventions are performed under general anaesthesia, although local or spinal anaesthesia are possible. Intravenous sedation with miniaturized instruments is especially suitable for female patients with distal ureteral stones. Antegrade URS is an option for large, impacted proximal ureteral calculi.

Safety aspects

Fluoroscopic equipment must be available in the operating room. If ureteral access is not possible, the insertion of a JJ stent followed by URS after a delay of 7-14 days offers an appropriate alternative to dilatation.

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

**Upgraded following panel consensus.*

Ureteral access sheaths

Hydrophilic-coated ureteral access sheaths (UAS), can be inserted via a guide wire, with the tip placed in the proximal ureter. Ureteral access sheaths allow easy multiple access to the upper urinary tract and therefore significantly facilitate URS. The use of UAS improves vision by establishing a continuous outflow, decrease intrarenal pressure and potentially reduce operating time.

Stone disintegration and extraction

The aim of endourological intervention is complete stone removal. 'Smash and go' strategies should be limited to the treatment of large renal stones. For flexible URS (RIRS) only

baskets made of Nitinol are suitable.

Recommendation	LE	GR
Stone extraction using a basket without endoscopic visualisation of the stone (blind basketing) should not be performed.	4	A*
Ho:YAG laser lithotripsy is the preferred method for (flexible) URS.	3	B

**Upgraded following panel consensus.*

Stenting before and after URS

Pre-stenting facilitates ureteroscopic management of stones, improves the stone-free rate, and reduces complications. Following URS, stents should be inserted in patients who are at increased risk of complications.

Recommendation	LE	GR
In uncomplicated URS, a stent need not be inserted.	1a	A
An α-blocker can reduce stent-related symptoms	1a	

Open surgery

Most stones should be approached primarily with PNL, URS, SWL, or a combination of these techniques. Open surgery may be a valid primary treatment option in selected cases.

Indications for open surgery:

- Complex stone burden
- Treatment failure of SWL and/or PNL, or URS
- Intrarenal anatomical abnormalities: infundibular stenosis, stone in the calyceal diverticulum (particularly in an anterior calyx), obstruction of the ureteropelvic junction,

stricture if endourologic procedures have failed or are not promising
- Morbid obesity
- Skeletal deformity, contractures and fixed deformities of hips and legs
- Comorbidity
- Concomitant open surgery
- Non-functioning lower pole (partial nephrectomy), non-functioning kidney (nephrectomy)
- Patient choice following failed minimally invasive procedures; the patient may prefer a single procedure and avoid the risk of needing more than one PNL procedure
- Stone in an ectopic kidney where percutaneous access and SWL may be difficult or impossible
- For the paediatric population, the same considerations apply as for adults.

Laparoscopic surgery

Indications for laparoscopic kidney-stone surgery include:
- complex stone burden;
- failed previous SWL and/or endourological procedures;
- anatomical abnormalities;
- morbid obesity;
- nephrectomy in case of non-functioning kidney.

Indications for laparoscopic ureteral stone surgery include:
- large, impacted stones;
- multiple ureteral stones;
- in cases of concurrent conditions requiring surgery;
- when other non-invasive or low-invasive procedures have failed.

If indicated, for upper ureteral calculi, laparoscopic urolithomy has the highest stone-free rate compared to URS and SWL (LE: 1a).

Recommendations	LE	GR
Laparoscopic or open surgical stone removal may be considered in rare cases where SWL, URS, and percutaneous URS 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. An exception is complex renal stone burden and/or stone location.	3	C
For ureterolithotomy, laparoscopy is recommended for large impact stones or when endoscopic lithotripsy or SWL have failed.	2	B

Indication for active stone removal and selection of procedure

Ureter:

- stones with a low likelihood of spontaneous passage;
- persistent pain despite adequate pain medication;
- persistent obstruction;
- renal insufficiency (renal failure, bilateral obstruction, single kidney).

Kidney:

- stone growth;
- stones in high-risk patients for stone formation;
- obstruction caused by stones;
- infection;
- symptomatic stones (e.g. pain, haematuria);
- stones > 15 mm;
- stones < 15 mm if observation is not the option of choice;
- patient preference (medical and social situation);
- comorbidity;
- choice of treatment.

The suspected stone composition might influence the choice of treatment modality.

Recommendations	GR
For asymptomatic caliceal stones in general, active surveillance with an annual follow-up of symptoms and stone status (KUB, ultrasonography [US], NCCT) is an option for 2-3 years, whereas intervention should be considered after this period provided patients are adequately informed.	C
Observation might be associated with a greater risk of necessitating more invasive procedures.	

STONE REMOVAL

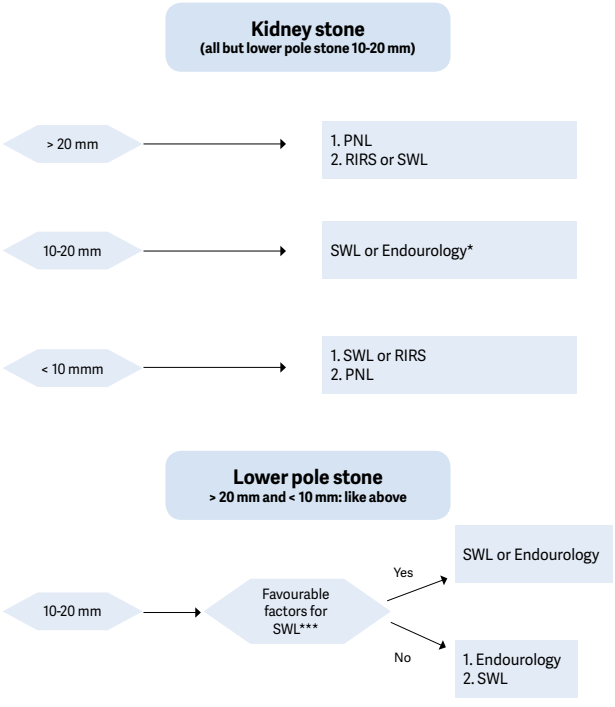
Recommendations	GR
Urine culture or urinary microscopy is mandatory before any treatment is planned and urinary infection should be treated ahead of stone removal.	A*
Anticoagulation therapy including salicylates should be stopped before stone removal.	B
If intervention for stone removal is essential and salicylate therapy should not be interrupted, retrograde URS is the preferred treatment of choice.	

**Upgraded based on panel consensus.*

Radiolucent uric acid stones, but not sodium urate or ammonium urate stones, can be dissolved by oral chemolysis.

Selection of procedure for active removal of renal stones**

Fig. 1: Treatment algorithm for renal calculi



** Flexible URS is used less as first-line therapy for renal stones > 1.5 cm.*

*** The ranking of the recommendations reflects a panel majority vote.*

**** see Table 19 extended document*

Selection of procedure for active stone removal of ureteral stones (GR: A*)

Stone location and size	First choice	Second choice
Proximal ureter < 10 mm	SWL	URS
Proximal ureter > 10 mm	URS (retrograde or antegrade) or SWL	
Distal ureter < 10 mm	URS or SWL	
Distal ureter > 10 mm	URS	SWL

**Upgraded following panel consensus.*

Recommendation	GR
Percutaneous antegrade removal of proximal ureteral stones is an alternative when SWL is not indicated or has failed, and when the upper urinary tract is not amenable to retrograde URS.	A

Steinstrasse

Steinstrasse occurs in 4% to 7% of cases after SWL, the major factor in steinstrasse formation is stone size.

Recommendations	LE	GR
Medical expulsion therapy increases the stone expulsion rate of steinstrasse.	1b	A
PCN is indicated for steinstrasse associated with UTI/fever.	4	C
SWL is indicated for steinstrasse when large stone fragments are present.	4	C
Ureteroscopy is indicated for symptomatic steinstrasse and treatment failure.	4	C

Residual stones

Recommendations	LE	GR
Identification of biochemical risk factors and appropriate stone prevention is particularly indicated in patients with residual fragments or stones.	1b	A
Patients with residual fragments or stones should be followed up regularly to monitor disease course.	4	C
After SWL and URS, MET is recommended using an α-blocker to improve fragment clearance.	1a	A
For well-disintegrated stone material in the lower calix, an inversion therapy with simultaneous mechanical percussion manoeuvre under enforced diuresis may facilitate stone clearance.	1a	B

The indication for active stone removal and selection of the procedure is based on the same criteria as for primary stone treatment and also includes repeat SWL.

Management of urinary stones and related problems during pregnancy

Recommendations	LE	GR
US is the method of choice for practical and safe evaluation of pregnant women.	1a	A
Conservative management should be the first-line treatment for all non-complicated cases of urolithiasis in pregnancy (except those that have clinical indications for intervention).		A

If intervention becomes necessary, placement of an internal stent, percutaneous nephrostomy, or ureteroscopy are treatment options.	3	
URS is a reasonable alternative to avoid long-term stenting/drainage.	2a	
Regular follow-up until final stone removal is necessary due to higher encrustation tendency of stents during pregnancy.		

Pregnancy remains an absolute contraindication for SWL.

Management of stone problems in children

Spontaneous passage of a stone and of fragments after SWL is more likely to occur in children than in adults (LE: 4). For paediatric patients, the indications for SWL and PNL are similar to those in adults, however they pass fragments more easily. Children with renal stones with a diameter up to 20 mm (~300 mm^2) are ideal candidates for SWL.

Recommendations	**GR**
Ultrasound evaluation is the first choice for imaging in children and should include the kidney, filled bladder and adjoining portions of the ureter.	A*
If US does not provide the required information, KUB radiography (or NCCT) should be performed.	B
In all paediatric patients all efforts should be made to collect stone material for analysis, followed by complete metabolic evaluation.	A

**Upgraded from B following panel consensus.*

Table 5: Stones in exceptional situations

Caliceal diverticulum stones	SWL, PNL (if possible) or RIRS (retrograde intrarenal surgery via flexible ureteroscopy).
	Can also be removed using laparoscopic retroperitoneal surgery.
	Patients may become asymptomatic due to stone disintegration (SWL) whilst well-disintegrated stone material remains in the original position.
Horseshoe kidneys	Can be treated in line with the stone treatment options described above.
	Passage of fragments after SWL might be poor.
Stones in pelvic kidneys	SWL, RIRS or laparoscopic surgery
	For obese patients, the options are SWL, PNL, RIRS or open surgery
Stones in transplanted kidneys	PNL, (flexible) URS, SWL. Metabolic evaluation based on stone analysis
Stones formed in urinary division	Individual management necessary.
	For smaller stones SWL is effective.
	PNL and antegrade flexible URS frequently used .

Stones formed in a continent reservoir	Present a varied and often difficult problem.
	Each stone problem must be considered and treated individually.
Stones in patients with neurogenic bladder disorder	All methods apply based on individual situation. Careful patient follow up and preventive strategies are important.
	In myelomeningocele-patients, latex allergy is common, appropriate measures needed.
Patients with obstruction of the ureteropelvic junction which needs correction	PNL followed by percutaneous endopyelotomy or open/laparoscopic surgery, or URS together endopyelothomy with Ho:YAG.
	Incision with an Acucise balloon catheter might be considered, provided the stones can be prevented from falling into the pelvo-ureteral incision.

Metabolic evaluation and recurrence prevention

Stone prevention is based on a reliable stone analysis and basic analysis as mentioned above. Every patient should be assigned to the low- or high risk group for stone formation. For both groups general preventive measures apply:

Fluid intake (drinking advice)	Fluid amount: 2.5-3.0 L/day Circadian drinking Neutral pH beverages Diuresis: 2.0-2.5 L/day Specific weight of urine: < 1010
Nutritional advice for a balanced diet	Balanced diet* Rich in vegetable and fibre Normal calcium content: 1-1.2 g/day Limited NaCl content: 4-5 g/day Limited animal protein content: 0.8-1.0 g/kg/day
Lifestyle advice to normalise general risk factors	BMI: 18-25 kg/m^2 (adults) Stress limitation measures Adequate physical activity Balancing of excessive fluid loss

For patients assigned to the high risk group of stone formers specific laboratory analysis of blood and urine including two consecutive 24-hour urine samples are necessary. For the specific metabolic work-up, the patient should stay on a self-determined diet under normal daily conditions and should ideally be stone free for at least 20 days, better 3 months. These findings are the basis for further recommendations:

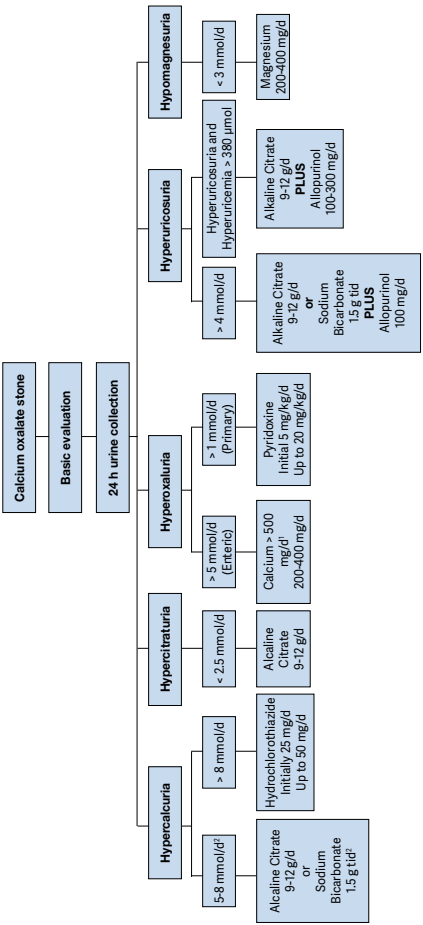
Recommendations on specific diet		LE	GR
Hyperoxaluria	Oxalate restriction	2b	B
High sodium excretion	Restricted intake of salt	1b	A
Small urine volume	Increased fluid intake	1b	A
Urea level indicating a high intake of animal protein	Avoid excessive intake of animal protein	1b	A

Recommendations for specific pharmacological treatment			
Urinary risk factor	**Suggested treatment**	**LE**	**GR**
Hypercalciuria	Thiazide + potassium citrate	1a	A
Hyperoxaluria	Oxalate restriction	2b	A
Enteric hyperoxaluria	Potassium citrate	3-4	C
	Calcium supplement	2	B
	Oxalate absorption	3	B
Hypocitraturia	Potassium citrate	1b	A

Calcium oxalate stones

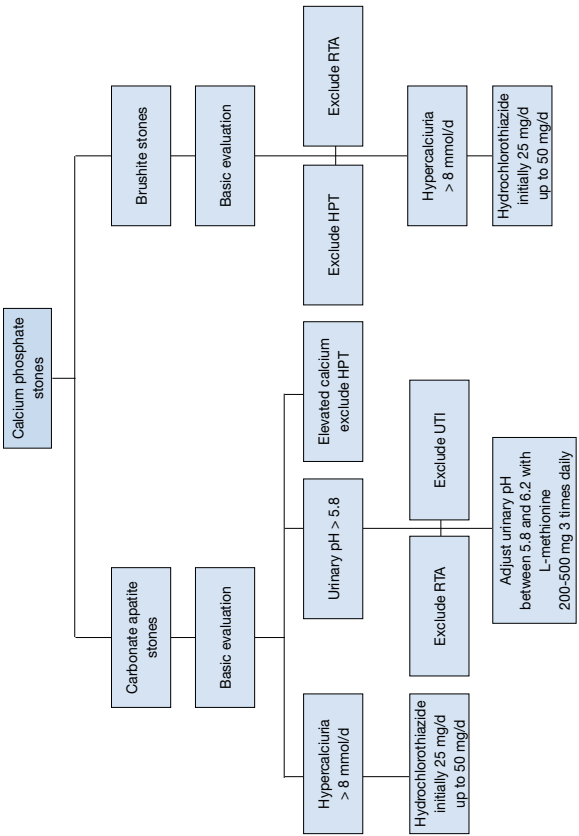
(Hyperparathyreoidism excluded by blood examination)

Fig. 2: Diagnostic and therapeutic algorithm for calcium oxalate stones



Calcium phosphate stones

Fig. 3: Diagnostic and therapeutic algorithm for calcium phosphate stones



Hyperparathyroidism

Elevated levels of ionized calcium in serum (or total calcium and albumin) require assessment of intact parathyroid hormone (PTH) to confirm or exclude suspected hyperparathyroidism (HPT). Primary HTP can only be cured by surgery.

Uric acid and ammonium urate stones

Fig 4: Diagnostic and therapeutic algorithm for uric acid and ammonium urate stones.

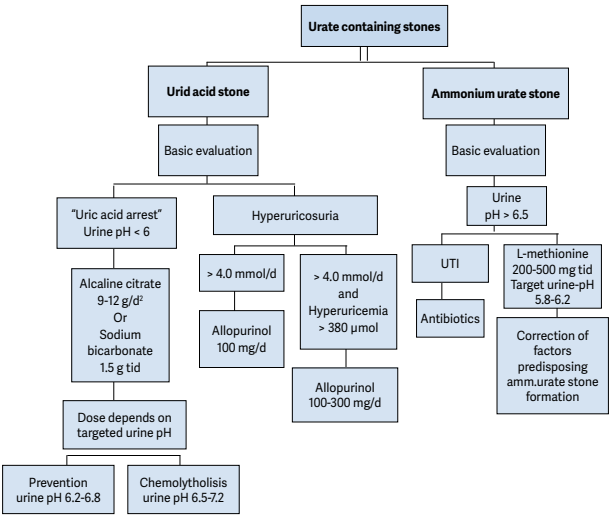
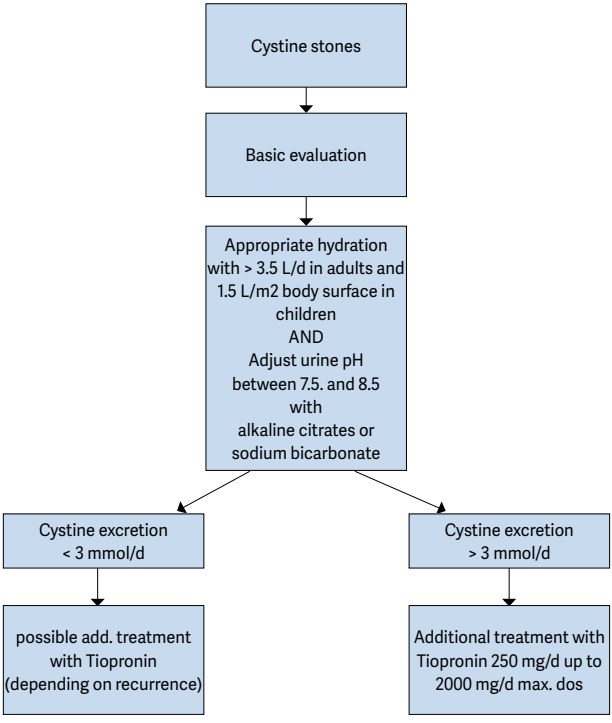


Fig 5: Metabolic management of cystine stones.



Struvite and infection stones

Recommendations Therapeutic measure	LE	GR
Surgical removal of the stone material as completely as possible.	3,4	A*
Short-term antibiotic course.	3	B
Long-term antibiotic course.	3	B
Urinary acidification: ammonium chloride; 1 g, 2 - 3 x daily.	3	B
Urinary acidification: methionine; 200-500 mg, 1 - 3 x daily.	3	B
Urease inhibition.	1b	A

Cystine stones

Therapeutic measures	LE	GR
Urine dilution High fluid intake recommended so that 24-h urine volume exceeds 3 L. Intake should be ≥ 150 mL/h.	3	B
Alkalinisation For cystine excretion < 3 mmol/day: potassium citrate 3–10 mmol 2 or 3 times daily, to achieve pH > 7.5.	3	B
Complex formation with cystine For patients with cystine excretion > 3 mmol/day, or when other measures are insufficient: tiopronin, 250–2000 mg/day. Captopril, 75–150 mg/day, remains a second-line option if tiopronin is not feasible or unsuccessful.	3	B

2,8-dihydroyadenine stones and xanthine stones

Both stone types are rare. In principle, diagnosis and specific prevention is similar to that of uric acid stones.

Drug stones

Drug stones are induced by pharmacological treatment. Two types exist:

- stones formed by crystallised compounds of the drug;
- stones formed due to unfavourable changes in urine composition under drug therapy.

Treatment includes general preventive measures and the avoidance of the respective drugs

Investigating a patient with stones of unknown composition

Investigation	Rationale for investigation
Medical history	– Stone history (former stone events, family history) – Dietary habits – Medication chart
Diagnostic imaging	– Ultrasound in case of a suspected stone – Unenhanced helical CT (Determination of the Houndsfield unit provides information about the possible stone composition)
Blood analysis	– Creatinine – Calcium (ionized calcium or total calcium + albumin) – Uric acid

Urinalysis	– Urine pH profile (measurement after each voiding, minimum 4 daily) – Dipstick test: leucocytes, erythrocytes, nitrite, protein, urine pH, specific weight – Urine culture – Microscopy of urinary sediment (morning urine) – Cyanide nitroprusside test (cystine exclusion)

Further examinations depend on the results of the investigations listed above.

This short booklet text is based on the more comprehensive EAU guidelines (ISBN 978-90-79754-71-7) available to all members of the European Association of Urology at their website, http://www.uroweb.org.