EAU Guidelines on

Urolithiasis

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1. INTRODUCTION

1.1 Aims and scope

The European Association of Urology (EAU) Urolithiasis Guidelines Panel has prepared these guidelines to help urologists assess evidence-based management of stones/calculi in the urinary tract and incorporate recommendations into clinical practice. This document covers most aspects of the disease, which is still a cause of significant morbidity despite technological and scientific advances. The Panel is aware of the geographical variations in healthcare provision. Originally available as a separate document, information on the management of bladder stones is now also included in these guidelines.

It must be emphasised that clinical guidelines present the best evidence available to the experts but following guideline recommendations will not necessarily result in the best outcome. Guidelines can never replace clinical expertise when making treatment decisions for individual patients, but rather help to focus decisions - also taking personal values and preferences/individual circumstances of patients into account. Guidelines are not mandates and do not purport to be a legal standard of care.

1.2 Panel composition

The EAU Urolithiasis Guidelines Panel consists of an international group of clinicians with particular expertise in this area. All experts involved in the production of this document have submitted potential conflict of interest statements, which can be viewed on the EAU, website Uroweb: http://uroweb.org/guideline/urolithiasis/.

1.3 Available publications

A quick reference document (Pocket guidelines) is available, both in print and as an app for iOS and Android devices. These are abridged versions, which may require consultation together with the full text versions. Several scientific publications are also available [1-3]. All documents can be accessed through the EAU website: http://uroweb.org/guideline/urolithiasis/.

1.4 Publication history and summary of changes

*1.4.1 **Publication history***

The EAU Urolithiasis Guidelines were first published in 2000. This 2022 document presents a limited update of the 2021 version.

*1.4.2 **Summary of changes***

The literature for the entire document has been checked and, wherever relevant, updated (see Methods section 2.1). References and supporting text have also been refreshed.

For 2022, several new sections have been added to these guidelines. These include chapter 3.5. Radiation exposure and protection during endourology and chapter 5. Follow-up of urinary stones. Throughout the text passages on best clinical practice for the use of different interventions have been added to the relevant sections. In addition, chapter 3.4.3 Medical expulsive therapy has been thoroughly revised and the Bladder Stones guidelines, previously a separate document, have been integrated into this text. Four new algorithms have also been added:

- Figure 4.2: Diagnostic algorithm for calcium oxalate stones
- Figure 4.6: Diagnostic algorithm for uric acid stones
- Figure 5.1: Follow-up duration of urinary stone patients after treatments
- Figure 5.2: Consensus on follow-up frequency and imaging modality to use after treatment

2. METHODS

2.1 Data identification

For the 2022 Urolithiasis Guidelines, new and relevant evidence has been identified, collated, and appraised through a structured assessment of the literature.

A broad and comprehensive scoping exercise covering all areas of the guideline was performed. The search was limited to studies representing high levels of evidence only (i.e., systematic reviews with meta-analysis (MA), randomised controlled trials (RCTs), and prospective non-randomised comparative studies) published in the English language. The search was restricted to articles published between 1st May 2020 and 12th May 2021. A total of 737 unique records were identified and screened for relevance.

For the 2022 Bladder Stones section, new and relevant evidence was identified, collated, and

appraised through a structured assessment of the literature. The search was limited to studies representing high levels of evidence only published in the English language. The search was restricted to articles published between April 2020 and April 2021. A total of 235 unique records were identified and screened for relevance.

In addition to this, several ancillary searches limited to studies representing high levels of evidence only and published in the English language were also carried out to underpin the new chapter 3.5. radiation exposure and protection during endourology, and to formulate best clinical practice statements. The five-year search, from 2016 to May 2021, on radiation exposure and urolithiasis returned a total of 117 unique records which were identified and screened for relevance. The remainder of the searches on specific interventions that could be used to formulate best clinical practice statements returned a total of 1,080 records which were identified and screened for relevance. These include a four-year search (2018-2021) on URS thulium fiber laser; five-year searches (2017-2021) on URS internal temperature, URS suction with fragmentation, URS intrarenal pressure, fluoroless URS, PNL suction, and PNL fluoroless; a six-year search (2016-2021) on single vs. reusable URS, and ten-year searches (2011-2021) on SWL, URS fibreoptic vs. digital, optimal laser, URS time limit operation, PNL anaesthesia, PNL thermal and PNL renal puncture.

Databases covered by the searches included Medline, EMBASE, Ovid and the Cochrane Libraries. The search strategies are published online: http://uroweb.org/guideline/urolithiasis/?type=appendices-publications.

A total of 59 new references have been added to the 2022 Urolithiasis Guidelines publication. The chapters on the treatment of bladder stones in adults and children are based on a systematic review [4].

For each recommendation within the guidelines there is an accompanying online strength rating form, the basis of which is a modified GRADE methodology [5, 6]. Each strength-rating form addresses a number of key elements, namely:

1. the overall quality of the evidence which exists for the recommendation, references used in this text are graded according to a classification system modified from the Oxford Centre for Evidence-Based Medicine Levels of Evidence [7];
2. the magnitude of the effect (individual or combined effects);
3. the certainty of the results (precision, consistency, heterogeneity and other statistical or study related factors);
4. the balance between desirable and undesirable outcomes;
5. the impact of patient values and preferences on the intervention;
6. the certainty of those patient values and preferences.

These key elements are the basis which panels use to define the strength rating of each recommendation. The strength of each recommendation is represented by the words ‘strong’ or ‘weak’ [8]. The strength of each recommendation is determined by the balance between desirable and undesirable consequences of alternative management strategies, the quality of the evidence (including certainty of estimates), and nature and variability of patient values and preferences.

Additional information can be found in the general Methodology section of this print, and online at the EAU website: http://www.uroweb.org/guideline/.

A list of associations endorsing the EAU Guidelines can also be viewed online at the above address.

2.2 Review

The 2015 Urolithiasis Guidelines were subjected to peer-review prior to publication. Chapter 6, detailing the treatment and follow-up of bladder stones was peer reviewed in 2019.

2.3 Future goals

For the 2023 text update the Urolithiasis Guidelines Panel aim to provide further guidance on the following topics:

- Further evaluate the highest evidence for best clinical practice in endourology.
- Perform a systematic review on patient and personnel radiation protection during endourology.
- Questioning the accuracy of stone size as the surrogate index for deciding upon the treatment of urinary stones.

3. GUIDELINES

3.1 Prevalence, aetiology, risk of recurrence

3.1.1 Introduction

Stone incidence depends on geographical, climatic, ethnic, dietary, and genetic factors. The recurrence risk is basically determined by the disease or disorder causing the stone formation. Accordingly, the prevalence rates for urinary stones vary from 1% to 20% [9]. In countries with a high standard of life such as Sweden, Canada or the USA, renal stone prevalence is notably high (> 10%). For some areas, an increase of more than 37% over the last 20 years has been reported [10-12]. There is emerging evidence linking nephrolithiasis to the risk of chronic kidney disease (CKD) [13].

Stones can be stratified into those caused by: infections, non-infectious causes, genetic defects [14]; or adverse drug effects (drug stones) (Table 3.1). See also section 3.2.

Table 3.1: Stones classified by aetiology

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

3.1.2 Stone composition

Stone composition is the basis for further diagnostic and management decisions. Stones are often formed from a mixture of substances. Table 3.2 lists the most clinically relevant substances and their mineral components.

Table 3.2: Stone composition

Chemical name	**Mineral name** [15]	**Chemical formula**
Calcium oxalate monohydrate	Whewellite	$CaC_2O_4.H_2O$
Calcium oxalate dihydrate	Weddelite	$CaC_2O_4.2H_2O$
Basic calcium phosphate	Apatite	$Ca_{10}(PO_4)_6.(OH)_2$
Calcium hydroxyl phosphate	Carbonate apatite	$Ca_5(PO_4)_3(OH)$
b-tricalcium phosphate	Whitlockite	$Ca_3(PO_4)_2$
Carbonate apatite phosphate	Dahllite	$Ca_5(PO_4)_3OH$
Calcium hydrogen phosphate dihydrate	Brushite	$CaHPO_4.2H_2O$
Calcium carbonate	Aragonite	$CaCO_3$
Octacalcium phosphate	-	$Ca_8H_2(PO_4)_6.5H_2O$
Uric acid	Uricite	$C_5H_4N_4O_3$
Uric acid dihydrate	Uricite	$C_5H_4O_3.2H_20$
Ammonium urate	-	$NH_4C_5H_3N_4O_3$
Sodium acid urate monohydrate	-	$NaC_5H_3N_4O_3.H_2O$
Magnesium ammonium phosphate hexahydrate	Struvite	$MgNH_4PO_4.6H_2O$
Magnesium acid phosphate trihydrate	Newberyite	-
Magnesium ammonium phosphate monohydrate	Dittmarite	-
Cystine	-	-
Xanthine	-	-
2,8-Dihydroxyadenine	-	-
Proteins	-	-
Cholesterol	-	-
Calcite	-	-
Potassium urate	-	-
Trimagnesium phosphate	-	-
Melamine	-	-
Matrix	-	-
Drug stones	Active compounds crystallising in urine	-
Foreign body calculi	-	-

3.1.3 Risk groups for stone formation

The risk status of stone formers is of particular interest because it defines the probability of recurrence or regrowth, the risk of CKD and mineral and bone disorder, and is imperative for pharmacological treatment. About 50% of recurrent stone formers have just one lifetime recurrence [11, 16]. A recent review of first-time stone formers calculated a recurrence rate of 26% in five years' time [17]. Highly recurrent disease is observed in slightly more than 10% of patients. Stone type and disease severity determine low- or high-risk stone formers (Table 3.3) [18, 19].

Table 3.3: High-risk stone formers [18-34]

General factors
Early onset of urolithiasis (especially children and teenagers)
Familial stone formation
Recurrent stone formers
Short time since last stone episode
Brushite-containing stones ($CaHPO_4.2H_2O$)
Uric acid and urate-containing stones
Infection stones
Solitary kidney (the kidney itself does not particularly increase the risk of stone formation, but prevention of stone recurrence is of more importance)
Diseases associated with stone formation
Hyperparathyroidism
Metabolic syndrome
Nephrocalcinosis
Polycystic kidney disease (PKD)
Gastrointestinal diseases (i.e., jejuno-ileal bypass, intestinal resection, Crohn's disease, malabsorptive conditions, enteric hyperoxaluria after urinary diversion, exocrine pancreatic insufficiency) and bariatric surgery
Increased levels of vitamin D
Sarcoidosis
Spinal cord injury, neurogenic bladder
Genetically determined stone formation
Cystinuria (type A, B and AB)
Primary hyperoxaluria (PH)
Renal tubular acidosis (RTA) type I
2,8-Dihydroxyadeninuria
Xanthinuria
Lesch-Nyhan syndrome
Cystic fibrosis
Drug-induced stone formation (see Table 4.11)
Anatomical abnormalities associated with stone formation
Medullary sponge kidney (tubular ectasia)
Ureteropelvic junction (UPJ) obstruction
Calyceal diverticulum, calyceal cyst
Ureteral stricture
Vesico-uretero-renal reflux
Horseshoe kidney
Ureterocele
Environmental and professional factors
High ambient temperatures
Chronic lead and cadmium exposure

A comprehensive evaluation of stone risk in patients should also include the risk of developing CKD, end-stage kidney disease (ESKD), and metabolic stone disease (Tables 3.4, 3.5 and 3.6). Urolithiasis can compromise renal function because of the renal stone (obstruction, infection), renal tissue damage due to the primary condition causing stone formation (some genetic diseases, nephrocalcinosis, enteric hyperoxaluria, etc.), or urological treatments for the condition [35]. Certain risk factors have been shown to be associated with such a risk in stone formers, as shown below.

Table 3.4 Risk factors for CKD and ESKD in stone formers

Risk factors for CKD/ESKD in stone formers
Female gender
Overweight
Frequent UTI
Struvite stones
Acquired single kidney
Neurogenic bladder
Previous obstructive nephropathy
Ileal conduit

Furthermore, some specific kinds of urolithiasis also carry a particular risk of developing CKD/ESKD as shown below.

Table 3.5 Risk factors for CKD and renal stones

Risk of chronic kidney disease and renal stones
• Possible risk of CKD
■ Xanthine stones
■ Indinavir stones
■ Distal renal tubular acidosis (incomplete)
■ Primary hyperparathyroidism
■ Eating disorders and laxative abuse
■ Medullary sponge kidney
• Moderate risk of CKD
■ Brushite stones
■ 2,8-Dihydroxyadenine stones
■ Sarcoidosis
■ Pyelo-ureteral or ureteral strictures
• High risk of CKD
■ Cystine stones
■ Struvite stones
■ Stones in a single kidney
■ Distal renal tubular acidosis (complete)
■ Secondary hyperoxaluria (bariatric surgery, inflammatory bowel disease, bowel resection and malabsorptive syndromes)
■ Other forms of nephrocalcinosis (often associated with genetic conditions with hypercalciuria)
■ Anatomical abnormalities of the kidney and urinary tract (for example, horseshoe kidney, ureterocele and vesicoureteral reflux)
■ Neurological bladder
• Very high risk of CKD
■ Primary hyperoxaluria
■ Autosomal dominant polycystic kidney

Table 3.6 Risk factors for metabolic bone disease and calcium renal stones

Risk of metabolic bone disease and calcium renal stones
• Distal renal tubular acidosis (complete or incomplete)
• Medullary sponge kidney
• Primary hyperparathyroidism
• Malabsorptive syndromes
• Fasting hypercalciuria
• Genetic disorders

3.2 Classification of stones

Urinary stones can be classified according to size, location, X-ray characteristics, aetiology of formation, composition, and risk of recurrence [11, 36, 37].

*3.2.1 **Stone size***

Stone size is usually given in one or two dimensions, and stratified into those measuring up to 5, 5-10, 10-20, and > 20 mm in largest diameter.

*3.2.2 **Stone location***

Stones can be classified according to anatomical 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 plain X-ray appearance [kidney-ureter-bladder (KUB) radiography] (Table 3.6), which varies according to mineral composition [37]. Non-contrast-enhanced computed tomography (NCCT) can be used to classify stones according to density, inner structure, and composition, which can affect treatment decisions (Section 3.3) [36, 37].

Table 3.7: X-ray characteristics

Radiopaque	Poor radiopacity	Radiolucent
Calcium oxalate dehydrate	Magnesium ammonium phosphate	Uric acid
Calcium oxalate monohydrate	Apatite	Ammonium urate
Calcium phosphates	Cystine	Xanthine
		2,8-Dihydroxyadenine
		Drug-stones (Section 4.11)

3.3 Diagnostic evaluation

*3.3.1 **Diagnostic imaging***

The most appropriate imaging modality will be determined by the clinical situation, which will differ depending on if a ureteral or renal stone is suspected.

Standard evaluation includes a detailed medical history and physical examination. Patients with ureteral stones usually present with loin pain, vomiting, and sometimes fever, but may also be asymptomatic [38]. Immediate evaluation is indicated in patients with solitary kidney, fever or when there is doubt regarding a diagnosis of renal colic. Ultrasound (US) should be used as the primary diagnostic imaging tool, although pain relief, or any other emergency measures, should not be delayed by imaging assessments. Ultrasound is safe (no risk of radiation), reproducible and inexpensive. It can identify stones located in the calyces, pelvis, and pyeloureteric and vesico-ureteral junctions (US with filled bladder), as well as in patients with upper urinary tract (UUT) dilatation. Ultrasound has a sensitivity of 45% and specificity of 94% for ureteral stones and a sensitivity of 45% and specificity of 88% for renal stones [39, 40].

The sensitivity and specificity of KUB is 44-77% [41]. Kidney-ureter-bladder radiography should not be performed if NCCT is being considered [42]; however, it is helpful in differentiating between radiolucent and radiopaque stones and should be used for comparison during follow-up.

3.3.1.1 Evaluation of patients with acute flank pain/suspected ureteral stones

Non-contrast-enhanced computed tomography has become the standard for diagnosing acute flank pain and has replaced intravenous urography (IVU). Non-contrast-enhanced CT can determine stone diameter and density. When stones are absent, the cause of abdominal pain should be identified. In evaluating patients with suspected acute urolithiasis, NCCT is significantly more accurate than IVU or US [43].

Non-contrast-enhanced CT can detect uric acid and xanthine stones, which are radiolucent on plain films, but not indinavir stones [44]. Non-contrast-enhanced CT can determine stone density, inner structure of the stone, skin-to-stone distance, and surrounding anatomy; all of which affect selection of treatment modality [37, 45-47]. The advantage of non-contrast imaging must be balanced against loss of information on renal function and urinary collecting system anatomy, as well as higher radiation dose [48-51].

Radiation risk can be reduced by low-dose CT, which may, however, be difficult to introduce in standard clinical practice [52-56]. In patients with a body mass index (BMI) < 30, low-dose CT has been shown to have a sensitivity of 86% for detecting ureteral stones < 3 mm and 100% for calculi > 3 mm [57]. A meta-analysis (MA) of prospective studies [54] has shown that low-dose CT diagnosed urolithiasis with a pooled sensitivity of 93.1% (95% CI: 91.5-94.4), and a specificity of 96.6% (95% CI: 95.1-97.7%). Dual-energy CT can differentiate uric acid containing stones from calcium-containing stones [58, 59].

Summary of evidence	LE
Non-contrast-enhanced CT is used to confirm stone diagnosis in patients with acute flank pain, as it is superior to IVU.	1a
Enhanced CT enables 3D reconstruction of the collecting system, as well as measurement of stone density and skin-to-stone distance.	2a

Recommendations	Strength rating
Immediate imaging is indicated with fever or solitary kidney, and when diagnosis is doubtful.	Strong
Use non-contrast-enhanced computed tomography to confirm stone diagnosis in patients with acute flank pain following initial ultrasound assessment.	Strong
Perform a contrast study if stone removal is planned and the anatomy of the renal collecting system needs to be assessed.	Strong

*3.3.2 **Diagnostics - metabolism-related***

Besides imaging, each emergency patient with urolithiasis needs a succinct biochemical work-up of urine and blood test. At this point, no distinction is made between high- and low-risk patients for stone formation.

3.3.2.1 Basic laboratory analysis - non-emergency urolithiasis patients

Biochemical work-up is similar for all stone patients. However, if no intervention is planned, examination of sodium, potassium, C-reactive protein (CRP), and blood coagulation time can be omitted. Only patients at high risk for stone recurrence should undergo a more specific analytical programme [19]. Stone-specific metabolic evaluation is described in chapter 4.

The easiest method for diagnosing stones is by analysis of a passed stone using a validated method as listed in section 3.3.2.3. Once the mineral composition is known, a potential metabolic disorder can be identified.

3.3.2.2 Analysis of stone composition

Stone analysis should be performed in all first-time stone formers.

In clinical practice, repeat stone analysis is needed in the case of:

- recurrence under pharmacological prevention;
- early recurrence after interventional therapy with complete stone clearance;
- late recurrence after a prolonged stone-free period [60, 61].

Patients should be instructed to filter their urine to retrieve a concrement for analysis. Stone passage and restoration of normal renal function should be confirmed.

The preferred analytical procedures are infrared spectroscopy (IRS) or X-ray diffraction (XRD) [62-64]. Equivalent results can be obtained by polarisation microscopy. Chemical analysis (wet chemistry) is generally deemed to be obsolete [62, 65].

3.3.2.3 Guidelines for laboratory examinations and stone analysis [19, 25, 66, 67]

Recommendations	Strength rating
Urine	
Dipstick test of spot urine sample: • red cells; • white cells; • nitrites; • approximate urine pH; • urine microscopy and/or culture.	Weak
Blood	
Serum blood sample: • creatinine; • uric acid; • (ionised) calcium; • sodium; • potassium; • blood cell count; • C-reactive protein.	Strong

Perform a coagulation test (partial thromboplastin time and international normalised ratio) if intervention is likely or planned.	Strong
Perform stone analysis in first-time formers using a valid procedure (X-ray diffraction or infrared spectroscopy).	Strong
Repeat stone analysis in patients presenting with: • recurrent stones despite drug therapy; • early recurrence after complete stone clearance; • late recurrence after a long stone-free period because stone composition may change.	Strong

*3.3.3 **Diagnosis in special groups and conditions***

3.3.3.1 Diagnostic imaging during pregnancy

In pregnant women radiation exposure may cause non-stochastic (teratogenesis) or stochastic (carcinogenesis, mutagenesis) effects. Teratogenic effects are cumulative with increasing dose and require a threshold dose (< 50 mGy are considered as safe) and depend on the gestation age (minimum risk prior to 8th week and after the 23rd week). Carcinogenesis (doses even < 10 mGy present a risk) and mutagenesis (500-1000 mGy doses are required, far in excess of the doses in common radiographic studies) get worse with increasing dose but they do not require a dose threshold and are not dependent on the gestational age [68].

There is no imaging modality that should be routinely repeated in pregnant women. Scientific societies and organisations agree on the safety of the diagnostic evaluation when US [69], X-ray imaging [70, 71], and MRI [72, 73] are used as and when indicated [74-80]. A radiographic procedure should not be withheld from a pregnant woman if the procedure is clearly indicated and doing so will affect her medical care.

It is generally recommended that an investigation resulting in an absorbed dose to the foetus of greater than 0.5 mGy requires justification.

Ultrasound (when necessary, using changes in renal resistive index and transvaginal/transabdominal US with a full bladder) has become the primary radiological diagnostic tool when evaluating pregnant patients suspected of renal colic. However, normal physiological changes in pregnancy can mimic ureteral obstruction [76-78].

Magnetic resonance imaging can be used, as a second-line option [74], to define the level of urinary tract obstruction, and to visualise stones as a filling defect [72]. As 3 Tesla (T) MRI has not been evaluated in pregnancy, the use of 1.5T is currently recommended [75, 80]. The use of gadolinium is not routinely recommended in pregnancy to avoid toxic effects to the embryo [76].

For the detection of urolithiasis during pregnancy, low-dose CT is associated with a higher positive predictive value (95.8%), compared to MRI (80%) and US (77%). As per White *et al*., low-dose CT offers improved diagnostic accuracy that can avoid negative interventions such as ureteroscopy [81]. Although low-dose CT protocols reduce the radiation exposure, judicious use is currently recommended in pregnant women as a last-line option [76].

Summary of evidence	**LE**
Only low-level data exist for imaging in pregnant women supporting US and MRI.	3

Recommendations	**Strength rating**
Use ultrasound as the preferred method of imaging in pregnant women.	Strong
Use magnetic resonance imaging as a second-line imaging modality in pregnant women.	Strong
Use low-dose computed tomography as a last-line option in pregnant women.	Strong

3.3.3.2 Diagnostic imaging in children

Children with urinary stones have a high risk of recurrence; therefore, standard diagnostic procedures for high-risk patients apply, including a valid stone analysis (section 3.1.3 and chapter 4). The most common non-metabolic disorders facilitating stone formation are vesico-ureteral reflux (VUR), UPJ obstruction, neurogenic bladder, and other voiding difficulties [82].

When selecting diagnostic procedures to identify urolithiasis in children, it should be remembered that these patients might be uncooperative, require anaesthesia, and may be sensitive to ionising radiation. Again, the principle of ALARA (As Low As Reasonably Achievable) should be observed [83-85].

Ultrasound

Ultrasound is the primary imaging technique [86] in children. Its advantages are absence of radiation and no need for anaesthesia. Imaging should include both the fluid-filled bladder with adjoining portion of the ureters, as well

as the upper ureter [87-91]. Colour Doppler US shows differences in the ureteral jet [88] and resistive index of the arciform arteries of both kidneys, which are indicative of the grade of obstruction [89]. Nevertheless, US fails to identify stones in > 40% of children [90-93] and provides limited information on renal function.

Plain films (KUB radiography)
Kidney-ureter-bladder radiography can help to identify stones and their radiopacity and facilitate follow-up.

Intravenous urography
The radiation dose for IVU is comparable to that for voiding cysto-urethrography (0.33 mSV) [94]. However, the need for contrast medium injection is a major drawback.

Non-contrast-enhanced computed tomography
Recent low-dose CT protocols have been shown to significantly reduce radiation exposure [51, 95, 96]. In children, only 5% of stones escape detection by NCCT [88, 96, 97]. Sedation or anaesthesia is rarely needed with modern high-speed CT equipment.

Magnetic resonance urography
Magnetic resonance urography (MRU) cannot be used to detect urinary stones. However, it might provide detailed anatomical information about the urinary collecting system, the location of an obstruction or stenosis in the ureter, and renal parenchymal morphology [98].

3.3.3.2.1 Summary of evidence and guidelines for diagnostic imaging in children

Summary of evidence	**LE**
Ultrasound is the first-line imaging modality in children when a stone is suspected; it should include the kidney, fluid-filled bladder, and the ureter next to the kidney.	2b
A kidney-ureter-bladder radiography (or low-dose NCCT) is an alternative investigation if US will not provide the required information.	2b

Recommendations	**Strength rating**
Complete a metabolic evaluation based on stone analysis in all children.	Strong
Collect stone material for analysis to classify the stone type.	Strong
Perform ultrasound as first-line imaging modality in children when a stone is suspected; it should include the kidney, fluid-filled bladder, and the ureter.	Strong
Perform a kidney-ureter-bladder radiography (or low-dose non-contrast-enhanced computed tomography) if ultrasound will not provide the required information.	Strong

3.4 Disease Management

3.4.1 Renal colic

Pain relief
Non-steroidal anti-inflammatory drugs (NSAIDs) (including metamizoledipyrone), and paracetamol are effective in patients with acute stone colic [99], and have better analgesic efficacy than opioids [100]. Ibuprofen compared to ketorolac is a more rapid acting drug in controlling pain caused by renal colic with a similar side effect profile [101].

Pain relief from intramuscular (i.m.) diclofenac compared favourably with those from intravenous (i.v.) ibuprofen and i.v. ketorolac; however, no recommendation can be given due to the manner in which the results have been reported [102]. The addition of antispasmodics to NSAIDs does not result in better pain control. Patients receiving NSAIDs are less likely to require further analgesia in the short term. It should be taken into consideration that the use of diclofenac and ibuprofen increased major coronary events [99, 100]. Diclofenac is contraindicated in patients with congestive heart failure (New York Heart Association class II-IV), ischaemic heart disease and peripheral arterial- and cerebrovascular disease. Patients with significant risk factors for cardiovascular events should be treated with diclofenac only after careful consideration. As risks increase with dose and duration, the lowest effective dose should be used for the shortest duration [103, 104].

Opioids, particularly pethidine, are associated with a high rate of vomiting compared to NSAIDs and carry a greater likelihood of further analgesia being needed [99, 105]. If an opioid is used, it is recommended that it is not pethidine. Data on other types of non-opioid and non-NSAID medication is increasing. Ketamine in

combination with morphine, compared to morphine alone, leads to morphine consumption reduction, less pain, nausea and vomiting [106-108]. Patients receiving ketamine and NSAIDs attained greater reduction in pain scores with less side effects, and better functional state, as well as less further analgesia requirement than those administered pethidine [109]. However, when comparing ketamine vs. NSAID (ketorolac) alone, equal efficacy but higher rates of dizziness, agitation and hypertension with ketamine were observed [110]. Conflicting results have been reported regarding the utility of i.v. lidocaine. Acupuncture seems to be effective in renal colic alone or in combination, but there is limited data [111, 112].

Prevention of recurrent renal colic

Facilitation of passage of ureteral stones is discussed in Section 3.4.9. For patients with ureteral stones that are expected to pass spontaneously, NSAID tablets or suppositories (e.g., diclofenac sodium, 100-150 mg/day, 3-10 days) may help reduce inflammation and the risk of recurrent pain [113, 114]. Although diclofenac can affect renal function in patients with already reduced function, it has no functional effect in patients with normal renal function [115].

The systematic review and MA by Hollingsworth *et al*., [116] addressed pain reduction as a secondary outcome and concluded that medical expulsive therapy (MET) seems efficacious in reducing pain episodes of patients with ureteral stones.

If analgesia cannot be achieved medically, drainage, using stenting, percutaneous nephrostomy, or stone removal, is indicated [117].

3.4.1.1 Summary of evidence and guidelines for the management of renal coli

Summary of evidence	**LE**
Non-steroidal anti-inflammatory drugs are very effective in treating renal colic and are superior to opioids.	1b
For symptomatic ureteral stones, stone removal as first-line treatment is a feasible option in selected patients.	1b

Recommendations	**Strength rating**
Offer a non-steroidal anti-inflammatory as the first drug of choice e.g., metamizole* (dipyrone); alternatively paracetamol or, depending on cardiovascular risk factors, diclofenac**, indomethacin or ibuprofen***.	Strong
Offer opioids (hydromorphine, pentazocine or tramadol) as a second choice.	Weak
Offer renal decompression or ureteroscopic stone removal in case of analgesic refractory colic pain.	Strong

* *Maximum single oral dose recommended 1000 mg, total daily dose up to 5000 mg, not recommended in the last three months of pregnancy [118].*

** *Affects glomerular filtration rate (GFR) in patients with reduced renal function.*

*** *Recommended to counteract recurrent pain after ureteral colic.*

*3.4.2 **Management of sepsis and/or anuria in obstructed kidney***

The obstructed kidney with all signs of urinary tract infection (UTI) and/or anuria is a urological emergency. Urgent decompression is often necessary to prevent further complications in infected hydronephrosis secondary to stone-induced, unilateral or bilateral, renal obstruction.

Decompression

Currently, there are two options for urgent decompression of obstructed collecting systems:

- placement of an indwelling ureteral stent;
- percutaneous placement of a nephrostomy tube.

There is little evidence to support the superiority of percutaneous nephrostomy over retrograde stenting for primary treatment of infected hydronephrosis. There is no good quality evidence to suggest that ureteral stenting has more complications than percutaneous nephrostomy [119, 120].

Only one RCT [121] compared different modalities of decompression of acute infected hydronephrosis. The complications of percutaneous nephrostomy insertion have been reported consistently, but those of ureteral stent insertion are less well described [119]. Definitive stone removal should be delayed until the infection is cleared following a complete course of antimicrobial therapy. A small RCT showed the feasibility of immediate ureteroscopic stone removal combined with an appropriate antibiotic regimen; however, at the cost of longer hospital stay and higher analgesic requirements [122].

Further measures

Following urgent decompression of the obstructed and infected urinary collecting system, both urine- and blood samples should be sent for culture-antibiogram sensitivity testing and antibiotics should be initiated immediately thereafter or continued, if initiated prior to testing. The regimen should be re-evaluated in the light of the culture-antibiogram results. Although clinically well accepted, the impact of a second antibiogram test on treatment outcome has not yet been evaluated. Intensive care might become necessary [123].

3.4.2.1 Summary of evidence and guidelines for the management of sepsis and anuria

Summary of evidence	LE
For decompression of the renal collecting system, ureteral stents and percutaneous nephrostomy catheters are equally effective.	1b

Recommendations	Strength rating
Urgently decompress the collecting system in case of sepsis with obstructing stones, using percutaneous drainage or ureteral stenting.	Strong
Delay definitive treatment of the stone until sepsis is resolved.	Strong
Collect (again) urine for antibiogram test following decompression.	Strong
Start antibiotics immediately (+ intensive care, if necessary).	Strong
Re-evaluate antibiotic regimen following antibiogram findings.	Strong

*3.4.3 **Medical expulsive therapy***

Several drug classes including α-blockers, calcium channel inhibitors and phosphodiesterase type 5 inhibitors (PDEI-5) are used for MET [124-127]. A class effect of α-blockers in MET has been demonstrated in MAs although this is an off-label indication [128-130]. However, there is contradictory evidence between these studies and several well-designed, multicentre, placebo-controlled, double-blinded randomised studies showing limited, or no, benefit using α-blockers, besides some advantage for distal ureteral stones > 5 mm [131-135]. Based on studies with a limited number of patients [127, 128, 136, 137], no recommendation for the use of PDEI-5 or corticosteroids in combination with α-blockers in MET can be made. The panel concludes that MET using α-blockers seems efficacious in the treatment of patients with distal ureteral stones > 5 mm who are amenable to conservative management. Medical expulsive therapy in special situations is addressed in the relevant chapters.

3.4.3.1 Summary of evidence and guideline for MET

Summary of evidence	LE
Medical expulsive therapy seems to be efficacious for treating patients with ureteral stones who are amenable to conservative management. The greatest benefit might be among those with > 5 mm (distal) ureteral stones.	1a
Insufficient data exist to support the use of PDEI-5 or corticosteroids in combination with α-blockers as an accelerating adjunct.	2a
Alpha-blockers increase stone expulsion rates in distal ureteral stones > 5 mm.	1a
A class effect of α-blockers has been demonstrated.	1a

Recommendation	Strength rating
Consider α-blockers for medical expulsive therapy as one of the treatment options for (distal) ureteral stones > 5 mm.	Strong

*3.4.4 **Chemolysis***

Percutaneous irrigation chemolysis

Percutaneous chemolysis is rarely used nowadays, for practical reasons. Percutaneous irrigation chemolysis may be an option for infection-stones and theoretically also for uric acid stones. For dissolution of struvite stones, Suby's G solution (10% hemiacidrin; pH 3.5-4) can be used. The method has been described in case series and literature reviews [138-140].

Oral chemolysis

Stones composed of uric acid, but not sodium or ammonium urate stones, can be dissolved by oral chemolysis. Prior stone analysis may provide information on stone composition. Urinary pH measurement and X-ray characteristics can provide information on the type of stone.

Oral chemolitholysis is based on alkalinisation of urine by application of alkaline citrate or sodium bicarbonate. The pH should be adjusted to 7.0-7.2. Chemolysis is more effective at a higher pH, which might, however, promote calcium phosphate stone formation. Patients will need to adjust the dosage of alkalising medication by self-monitoring the pH of their urine. No RCTs are available for this therapy, which has been in use for decades. Rodman, *et al*., [141] reviewed the principles and provided guidance to its clinical use, which was supported by Becker, *et al*., in 2007 [142] and Elsawy *et al*., in 2019 [143]. Monitoring of radiolucent stones during therapy is the domain of US; however, repeat-NCCT might be necessary [141, 142].

In the case of uric acid obstruction of the collecting system, oral chemolysis in combination with urinary drainage is indicated [144]. A combination of alkalinisation with tamsulosin can increase the frequency of spontaneous passage of distal ureteral uric acid stones as shown in one RCT for stones > 5 mm [144]. Additional shock wave lithotripsy (SWL) might help to improve the results but evidence is weak [145].

3.4.4.1 Summary of evidence and guidelines for chemolysis

Summary of evidence	**LE**
Irrigation chemolysis has been used in limited clinical settings to dissolve struvite stones.	3
Uric acid stones > 5mm can be dissolved based on oral alkalinisation of the urine above 7.0.	3
For obstructing uric acid stones, a combination of oral chemolysis with tamsulosin is more effective than each substance alone, particularly in stones > 8 mm.	1b

Recommendations (oral chemolysis of uric acid stones)	**Strength rating**
Inform the patient how to monitor urine-pH by dipstick and to modify the dosage of alkalising medication according to urine pH, as changes in urine pH are a direct consequence of such medication.	Strong
Carefully monitor patients during/after oral chemolysis of uric acid stones.	Strong
Combine oral chemolysis with tamsulosin in case of (larger) ureteral stones (if active intervention is not indicated).	Weak

*3.4.5 **Extracorporeal shock wave lithotripsy (ESWL)***

The success of SWL depends on the efficacy of the lithotripter and the following factors:

- size, location (ureteral, pelvic or calyceal), and composition (hardness) of the stones (Section 3.4.9.3);
- patient's habitus (Section 3.4.10.3);
- performance of SWL (best practice, see below).

Each of these factors significantly influences the retreatment rate and final outcome of SWL.

Best clinical practice

Stenting

Routine use of internal stents before SWL does not improve stone free rates (SFRs), nor lowers the number of auxiliary treatments. It may, however, reduce formation of steinstrasse [146-149].

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 [150].

Shock wave rate

Lowering shock wave frequency from 120 to 60-90 shock waves/min improves SFRs [151-159]. Ultraslow frequency 30 shock waves/min may increase SFR [160]. Tissue damage increases with shock wave frequency [161-164].

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 shock wave power. There is no consensus on the maximum number of shock waves [165]. Starting SWL on a lower energy setting with stepwise power (and SWL sequence) ramping can achieve vasoconstriction during

treatment [161], which prevents renal injury [166-168]. Animal studies [169] and a prospective randomised study [170] have shown better SFRs (96% vs. 72%) using stepwise power ramping, but no difference has been found for fragmentation or evidence of complications after SWL, irrespective of whether ramping was used [171, 172].

There are no conclusive data on the intervals required between repeated SWL sessions. However, clinical experience indicates that repeat sessions are feasible (within one day for ureteral stones) [173].

Improvement of acoustic coupling

Proper acoustic coupling between the cushion of the treatment head and the patient's skin is important. Defects (air pockets) in the coupling gel deflect 99% of shock waves [174]. Ultrasound gel is probably the most widely-used agent available as a lithotripsy coupling agent [175].

Procedural control

Results of treatment are operator dependent, and experienced clinicians obtain better results. During the procedure, careful imaging control of localisation contributes to outcome quality [176].

Pain Control

Careful control of pain during treatment is necessary to limit pain-induced movements and excessive respiratory excursions [177-180].

Antibiotic prophylaxis

No standard antibiotic prophylaxis before SWL is recommended. However, prophylaxis is recommended in the case of internal stent placement ahead of anticipated treatments and in the presence of increased bacterial burden (e.g., indwelling catheter, nephrostomy tube, or infectious stones) [67, 181, 182].

Medical therapy following ESWL

Despite conflicting results, most RCTs and several MAs support MET after SWL for ureteral or renal stones as adjunct to expedite expulsion and to increase SFRs. Medical expulsion therapy might also reduce analgesic requirements [183-192].

Post-treatment management

Mechanical percussion and diuretic therapy can significantly improve SFRs and accelerate stone passage after SWL [193-196].

Complications of extracorporeal shock wave lithotripsy

Compared to percutaneous nephrolithotomy (PNL) and ureteroscopy (URS), there are fewer overall complications with SWL [197, 198] (Table 3.8). The relationship between SWL and hypertension or diabetes is unclear. Published data are contradictory; however, no evidence exists supporting the hypothesis that SWL may cause long-term adverse effects [199-205].

Table 3.8: Shock wave lithotripsy-related complications [196-210]

Complications			**%**	**Reference**
Related to stone fragments	Steinstrasse		4 – 7	[218-220]
	Regrowth of residual fragments		21 – 59	[207, 208]
	Renal colic		2 – 4	[209]
Infections	Bacteriuria in non-infection stones		7.7 – 23	[207, 210]
	Sepsis		1 – 2.7	[207, 210]
Tissue effect	Renal	Haematoma, symptomatic	< 1	[211]
		Haematoma, asymptomatic	4 – 19	[211]
	Cardiovascular	Dysrhythmia	11 – 59	[207, 212]
		Morbid cardiac events	Case reports	[207, 212]
	Gastrointestinal	Bowel perforation	Case reports	[213-215]
		Liver, spleen haematoma	Case reports	[206, 215-217]

3.4.5.1 *Summary of evidence and guidelines for SWL*

Summary of evidence	LE
Stepwise power ramping prevents renal injury.	1b
Clinical experience has shown that repeat sessions are feasible (within one day for ureteral stones).	4
Optimal shock wave frequency is 1.0 to 1.5 Hz.	1a
Proper acoustic coupling between the cushion of the treatment head and the patient's skin is important.	2
Careful imaging control of localisation of stone contributes to outcome of treatment.	2a
Careful control of pain during treatment is necessary to limit pain-induced movements and excessive respiratory excursions.	1a
Antibiotic prophylaxis is recommended in the case of internal stent placement, infected stones, or bacteriuria.	1a

Recommendations	Strength rating
Ensure correct use of the coupling agent because this is crucial for effective shock wave transportation.	Strong
Maintain careful fluoroscopic and/or ultrasonographic monitoring during shock wave lithotripsy (SWL).	Strong
Use proper analgesia because it improves treatment results by limiting pain-induced movements and excessive respiratory excursions.	Strong
Prescribe antibiotics prior to SWL in the case of infected stones or bacteriuria.	Strong

3.4.6 ***Ureteroscopy (retrograde and antegrade)***

The current standard for rigid ureteroscopes is a tip diameter of < 8 French (F). Rigid URS can be used for the whole ureter [199]. However, technical improvements, as well as the availability of digital scopes, also favour the use of flexible ureteroscopes in the ureter [221].

Percutaneous antegrade removal of ureteral stones is a consideration in selected cases, i.e., large (> 15 mm), impacted proximal ureteral calculi in a dilated renal collecting system [222-224], or when the ureter is not amenable to retrograde manipulation [224-228].

Ureteroscopy for renal stones (RIRS)

Technical improvements including endoscope miniaturisation, improved deflection mechanism, enhanced optical quality and tools, and introduction of disposables have led to an increased use of URS for both renal and ureteral stones. Major technological progress has been achieved for RIRS. A recent systematic review addressing renal stones > 2 cm showed a cumulative SFR of 91% with 1.45 procedures/patient; 4.5% of the complications were > Clavien 3 [221, 229, 230]. Digital scopes demonstrate shorter operation times due to the improvement in image quality [229].

Stones that cannot be extracted directly must be disintegrated. If it is difficult to access stones within the lower renal pole that need disintegration; it may help to displace them into a more accessible calyx [231].

Best clinical practice in ureteroscopy

Access to the upper urinary tract

Most interventions are performed under general anaesthesia, although local or spinal anaesthesia is possible [232]. Intravenous sedation is suitable for female patients with distal ureteral stones [233]. Antegrade URS is an option for large, impacted, proximal ureteral calculi [222-224, 234]. Reduction of flexible ureteroscope diameter may provide similar vision, deflection, and manoeuvrability to standard flexible ureteroscopes potentially with improved ureteric access [235]. Disposable ureteroscopes provides similar safety and clinical effectiveness to reusable scopes. Concerns regarding the cost effectiveness remain [236, 237].

Safety aspects

Fluoroscopic equipment must be available in the operating room. The Panel recommend placement of a safety wire, even though some groups have demonstrated that URS can be performed without it [238-240]. Balloon and plastic dilators should be available, if necessary.

Prior rigid URS can be helpful for optical dilatation followed by flexible URS, if necessary. If ureteral access is not possible, insertion of a JJ stent followed by URS after seven to fourteen days offers an alternative [241]. Bilateral URS during the same session is feasible resulting in equivalent-to-lower SFRs, but slightly higher overall complication rates (mostly minor, Clavien 1 and 2) [242, 243].

Difficult lower pole anatomy such as steep infundibulopelvic angle predisposes to failure during RIRS [244]. Prolonged operative times are linked to increased complication rates in ureteroscopy, and efforts must be made to keep it below 90 minutes [245].

Ureteral access sheaths

Hydrophilic-coated ureteral access sheaths, which are available in different calibres (inner diameter from 9 F upwards), can be inserted (via a guide wire) with the tip placed in the proximal ureter.

Ureteral access sheaths allow easy, multiple, access to the UUT and therefore significantly facilitate URS. The use of ureteral access sheaths improves vision by establishing a continuous outflow, decreases intrarenal pressure, and potentially reduces operating time [246, 247].

The insertion of ureteral access sheaths may lead to ureteral damage, the risk is lowest in presented systems [248]. No data on long-term side effects are available [248, 249]. Whilst larger cohort series showed no difference in SFRs and ureteral damage (stricture rates of about 1.8%), they did show lower post-operative infectious complications [250, 251]. The use of ureteral access sheath is safe and can be useful for large and multiple renal stones or if long procedural time is expected [252].

Stone extraction

The aim of URS is complete stone removal. “Dust and go” strategies should be limited to the treatment of large (renal) stones [253]. Stones can be extracted by endoscopic forceps or baskets. Only baskets made of nitinol can be used for flexible URS [254].

Intracorporeal lithotripsy

The most effective lithotripsy system is the holmium: yttrium-aluminium-garnet (Ho:YAG) laser, which is currently the optimum standard for URS and flexible nephroscopy (Section 3.4.6), because it is effective in all stone types [255, 256]. Compared to low-power lasers, high-power laser reduces procedural time although the reported difference in clinical outcomes were non-significant [257] (J Pneumatic and US systems can be used with high disintegration efficacy in rigid URS [258, 259]). However, stone migration into the kidney is a common problem, which can be prevented by placement of special anti-migration tools proximal of the stone [260]. Medical expulsion therapy following Ho:YAG laser lithotripsy increases SFRs and reduces colic episodes [261]. Thulium fiber laser (TFL) for stone disease has a promising role and offers good clinical outcomes, which seem to be comparable to Ho:YAG laser (holmium) laser. More comparative clinical studies are, however, needed between these two modalities [262, 263].

Stenting before and after URS

Routine stenting is not necessary before URS. However, pre-stenting facilitates ureteroscopic management of stones, improves the SFR, and reduces intra-operative complications [264, 265].

Randomised prospective trials have found that routine stenting after uncomplicated URS (complete stone removal) is not necessary; stenting might be associated with higher post-operative morbidity and costs [266-269]. A ureteral catheter with a shorter indwelling time (one day) may also be used, with similar results [270].

Stents should be inserted in patients who are at increased risk of complications (e.g., ureteral trauma, residual fragments, bleeding, perforation, UTIs, or pregnancy), and in all doubtful cases, to avoid stressful emergencies. The ideal duration of stenting is not known. Most urologists favour one to two weeks after URS. Alpha-blockers reduce the morbidity of ureteral stents and increase tolerability [271, 272].

Medical expulsive therapy before and after ureteroscopy

Medical expulsion therapy before URS might reduce the risk for intra-operative ureteral dilatation, protect against ureteral injury and increase stone free rates four weeks after URS [273].

Medical expulsion therapy following Ho:YAG laser lithotripsy accelerates the spontaneous passage of fragments and reduces episodes of colic [261].

Complications of ureteroscopy

The overall complication rate after URS is 9-25% [199, 274, 275]. Most complications are minor and do not require intervention. There is evidence suggesting a risk of post-operative urosepsis of up to 5% [276, 277]. Ureteral avulsion and strictures are rare (< 1%). Previous perforations, pre-operative positive urine cultures and longer operation time are the most important risk factor for complications [245, 278]. Infectious complications following URS can be minimised using prophylactic antibiotics, limiting stent dwell and procedural time, identification and treatment of UTI, and planning in patients with large stone burden and multiple comorbidities [279].

High intrarenal pressure (IRP) predisposes to URS complications, and measures should be used to reduce IRP. Currently there are no accurate ways to measure intra-operative IRP [280].

3.4.6.1 Summary of evidence and guidelines for retrograde URS, RIRS and antegrade ureteroscopy

Summary of evidence	**LE**
In uncomplicated URS, a post-procedure stent need not be inserted.	1a
In URS (in particular for renal stones), pre-stenting has been shown to improve outcomes.	1b
An α-blocker can reduce stent-related symptoms and colic episodes.	1a
Medical expulsion therapy following Ho:YAG laser lithotripsy accelerates the spontaneous passage of fragments, increases SFRs, and reduces episodes of colic.	1b
The most effective lithotripsy system for flexible ureteroscopy is the Ho:YAG laser.	2a
Pneumatic and US systems can be used with high disintegration efficacy in rigid URS.	2a
Percutaneous antegrade removal of proximal ureter stones, or laparoscopic ureterolithotomy are feasible alternatives to retrograde ureteroscopy, in selected cases.	1b

Recommendations	**Strength rating**
Use holmium: yttrium-aluminium-garnet (Ho:YAG) laser lithotripsy for (flexible) ureteroscopy (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 shock wave lithotripsy (SWL) is not indicated or has failed, and when the upper urinary tract is not amenable to retrograde URS.	Strong
Use flexible URS in cases where percutaneous nephrolithotomy or SWL are not an option (even for stones > 2 cm). However, in this case there is a higher risk that a follow-up procedure and placement of a ureteral stent may be needed.	Strong

*3.4.7 **Percutaneous nephrolithotomy***

Percutaneous nephrolithotomy remains the standard procedure for large renal calculi. Different rigid and flexible endoscopes are available, and the selection is mainly based on the surgeon's own reference. Standard access tracts are 24-30 F. Smaller access sheaths, < 18 F, were initially introduced for paediatric use, but are now increasingly utilised in the adult population [281, 282].

Contraindications

Patients receiving anti-coagulant therapy must be monitored carefully pre- and post-operatively. Anti-coagulant therapy must be discontinued before PNL [283].

Other important contraindications include:

- untreated UTI;
- tumour in the presumptive access tract area;
- potential malignant kidney tumour;
- pregnancy (Section 3.4.14.1).

Best clinical practice

Intracorporeal lithotripsy

Several methods for intracorporeal lithotripsy during PNL are available. Ultrasonic and pneumatic systems are most commonly used for rigid nephroscopy, whilst laser is increasingly used for miniaturised instruments [284]. Flexible endoscopes also require laser lithotripsy to maintain tip deflection, with the Ho:YAG laser having become the standard.

Pre-operative imaging

Pre-procedural imaging evaluations are summarised in Section 3.3.1. In particular, US or CT of the kidney and the surrounding structures can provide information regarding interposed organs within the planned percutaneous path (e.g., spleen, liver, large bowel, pleura, and lung).

Positioning of the patient

Both prone and supine positions are equally safe, although the supine position confers some advantages, it depends on appropriate equipment being available to position the patient correctly, for example, X-ray devices and an operating table. Most studies cannot demonstrate an advantage of supine PNL in terms of operation time. Prone position offers more options for puncture and is therefore preferred for upper pole or multiple accesses [285, 286]. On the other hand, supine position allows simultaneous retrograde access to the collecting system, using flexible ureteroscope (ECIRS) [287].

Puncture

Although fluoroscopy is the most common intra-operative imaging method, the (additional) use of US reduces radiation exposure [288-290]. Pre-operative CT or intra-operative US allows identification of the tissue between the skin and kidney and lowers the incidence of visceral injury. The calyceal puncture may be done under direct visualisation using simultaneous flexible URS [289, 291, 292].

Dilatation

Dilatation of the percutaneous access tract can be achieved using a metallic telescope, single (serial) dilators, or a balloon dilatator. During PNL, safety and effectiveness are similar for different tract dilatation methods [293]. Although there are papers demonstrating that single step dilation is equally effective as other methods and that US only can be used for the dilatation, the difference in outcomes is most likely related to surgeon experience rather than to the technology used [293, 294].

Choice of instruments

The Panel performed a systematic review assessing the outcomes of PNL using smaller tract sizes (< 22 F, mini-PNL) for removing renal calculi [282]. Stone-free rates were comparable in miniaturised and standard PNL procedures. Procedures performed with small instruments tend to be associated with significantly lower blood loss, but the duration of procedure tends to be significantly longer. There were no significant differences in any other complications. However, the quality of the evidence was poor with only two RCTs and the majority of the remaining studies were single-arm case series only. Furthermore, the tract sizes used, and types of stones treated, were heterogeneous; therefore, the risk of bias and confounding were high. There is some evidence of using suction during PNL to reduce intra-renal pressure and increase stone free rate [295].

Nephrostomy and stents

The decision on whether, or not, to place a nephrostomy tube at the conclusion of the PNL procedure depends on several factors, including:

- presence of residual stones;
- likelihood of a second-look procedure;
- significant intra-operative blood loss;
- urine extravasation;
- ureteral obstruction;
- potential persistent bacteriuria due to infected stones;
- solitary kidney;
- bleeding diathesis;
- planned percutaneous chemolitholysis.

Small-bore nephrostomies seem to have advantages in terms of post-operative pain [282, 296, 297]. Tubeless PNL is performed without a nephrostomy tube. When neither a nephrostomy tube nor a ureteral stent is introduced, the procedure is known as totally tubeless PNL [298]. In uncomplicated cases, the latter procedure results in a shorter hospital stay, with no disadvantages reported [299].

Complications of percutaneous nephrolithotomy

A systematic review of almost 12,000 patients shows the incidence of complications associated with PNL; fever 10.8%, transfusion 7%, thoracic complication 1.5%, sepsis 0.5%, organ injury 0.4%, embolisation 0.4%, urinoma 0.2%, and death 0.05% [300].

Peri-operative fever can occur, even with a sterile pre-operative urinary culture and peri-operative antibiotic prophylaxis, because the renal stones themselves may be a source of infection. Intra-operative renal stone culture may therefore help to select post-operative antibiotics [301, 302]. Intra-operative irrigation pressure < 30 mmHg and unobstructed post-operative urinary drainage may be important factors in preventing post-operative sepsis [303]. Bleeding after PNL may be treated by briefly clamping the nephrostomy tube. Super-selective embolic occlusion of the arterial branch may become necessary in the case of severe bleeding.

High intrarenal pressure (IRP) predisposes to PNL complications, and measures should be used to reduce IRP. Currently there are no accurate ways to measure intra-operative intrarenal pressure [280].

3.4.7.1 Summary of evidence and guidelines for endourology techniques for renal stone removal

Summary of evidence	LE
Imaging of the kidney with US or CT can provide information regarding inter-positioned organs within the planned percutaneous path (e.g., spleen, liver, large bowel, pleura, and lung).	1a
Both prone and supine positions are equally safe, but neither has a proven advantage in operating time or SFR.	1a
Percutaneous nephrolithotomy performed with small instruments tends to be associated with significantly lower blood loss, but the duration of procedure tended to be significantly longer. There are no significant differences in SFR or any other complications.	1a
In uncomplicated cases, a totally tubeless PNL results in a shorter hospital stay, with no increase in complication rate.	1a

Recommendations	Strength rating
Perform pre-procedural imaging, including contrast medium where possible or retrograde study when starting the procedure, to assess stone comprehensiveness and anatomy of the collecting system to ensure safe access to the renal stone.	Strong
Perform a tubeless (without nephrostomy tube) or totally tubeless (without nephrostomy tube and ureteral stent) percutaneous nephrolithotomy procedure, in uncomplicated cases.	Strong

*3.4.8 **General recommendations and precautions for stone removal***

3.4.8.1 Antibiotic therapy

Urinary tract infections should always be treated if stone removal is planned. In patients with clinically significant infection and obstruction, drainage should be performed for several days before starting stone removal. A urine culture or urinary microscopy should be performed before treatment [304].

Peri-operative antibiotic prophylaxis

For prevention of infection following URS and percutaneous stone removal, no clear-cut evidence exists [279, 305]. In a review of a large database of patients undergoing PNL, it was found that in patients with negative baseline urine culture, antibiotic prophylaxis significantly reduced the rate of post-operative fever and other complications [306]. Single dose administration was found to be sufficient [307]. Pre-operative prophylactic antibiotics compared to single dose before anaesthesia significantly reduced post-operative sepsis (OR: 0.31, 95% CI: 0.20–0.50; P < 0.00001) and fever (OR: 0.26, 95% CI: 0.14–0.48; P < 0.0001) [301].

Recommendations	Strength rating
Obtain a urine culture or perform urinary microscopy before any treatment is planned.	Strong
Exclude or treat urinary tract infections prior to stone removal.	Strong
Offer peri-operative antibiotic prophylaxis to all patients undergoing endourological treatment.	Strong

3.4.8.2 Antithrombotic therapy and stone treatment

Patients with a bleeding disorder, or receiving antithrombotic therapy, should be referred to an internist for appropriate therapeutic measures before deciding on stone management [308-312]. In patients with an uncontrolled bleeding disorder, the following are at elevated risk of haemorrhage or perinephric haematoma (PNH) (high-risk procedures):

- SWL (hazard ratio of PNH up to 4.2 during anti-coagulant/anti-platelet medication [313-315]);
- PNL;
- percutaneous nephrostomy;
- laparoscopic surgery;
- open surgery [308].

Shock wave lithotripsy is feasible and safe after correction of the underlying coagulopathy [316-320]. In the case of an uncontrolled bleeding disorder or continued antithrombotic therapy, URS in contrast to SWL and PNL, might offer an alternative approach since it is associated with less morbidity [321-323]. Despite

appropriate cessation of anti-platelet agents, following standardised protocols prolonged haematuria in tube drainage after PNL has been reported [324]. Only data on flexible URS are available which support the superiority of URS in the treatment of proximal ureteral stones [325, 326]. Although URS is safe in patients with bleeding disorders or anticoagulation, an individualised patient-approach is necessary [323].

Table 3.9: Risk stratification for bleeding [310-312, 327]

Low-risk bleeding procedures	Cystoscopy Flexible cystoscopy Ureteral catheterisation Extraction of ureteral stent Ureteroscopy
High-risk bleeding procedures	Shock wave lithotripsy Percutaneous nephrostomy Percutaneous nephrolithotomy

Table 3.10: Suggested strategy for antithrombotic therapy in stone removal [310-312]
In collaboration with a cardiologist/internist weigh the risks and benefits of discontinuation of therapy, vs. delaying elective surgical procedures.

Medication/Agent	**Bleeding risk of planned procedure**	**Risk of thromboembolism**		
		Low risk	**Intermediate risk**	**High risk**
Warfarin Dabigatran Rivaroxaban Apixaban	Low-risk procedure	May be continued	Bridging therapy	Bridging therapy
	High-risk procedure	May be temporarily discontinued at appropriate interval. Bridging therapy is strongly recommended.	Bridging therapy	Bridging therapy
Aspirin	Low-risk procedure	Continue	Continue	Elective surgery: postpone. Non deferrable surgery: continue.
	High-risk procedure	Discontinue	Elective surgery: postpone. Non-deferrable surgery: continue, if is possible.	Elective surgery: postpone. Non-deferrable surgery: continue.
Thienopyridine agents (P2Y12 receptor inhibitors)	Low-risk procedure	Discontinue five days before intervention. Resume within 24-72 hours with a loading dose.	Continue	Elective surgery: postpone. Non-deferrable surgery: continue.
	High-risk procedure	Discontinue five days before intervention and resume within 24-72 hours with a loading dose.	Elective surgery: postpone. Non-deferrable surgery: discontinue five days before procedure and resume within 24-72 hours with a loading dose. Bridging therapy -glycoprotein IIb/IIIa inhibitors if aspirin is discontinued.	Elective surgery: postpone. Non-deferrable surgery: discontinue five days before procedure and resume within 24-72 hours, with a loading dose. Bridging therapy -glycoprotein IIb/IIIa inhibitors.

3.4.8.2.1 Summary of evidence and guidelines for antithrombotic therapy and stone treatment

Summary of evidence	LE
Active surveillance is indicated in patients at high risk for thrombotic complications in the presence of an asymptomatic calyceal stone.	4
The temporary discontinuation, or bridging of antithrombotic therapy in high-risk patients, should be discussed with the internist.	3
Retrograde (flexible) URS stone removal is associated with less morbidity in patients when antithrombotic therapy cannot be discontinued.	2a

Recommendations	Strength rating
Offer active surveillance to patients at high risk of thrombotic complications in the presence of an asymptomatic calyceal stone.	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 since it is associated with less morbidity.	Strong

3.4.8.3 Obesity

A high BMI can pose a higher anaesthetic risk and a lower success rate after SWL and PNL and may influence the choice of treatment [328].

3.4.8.4 Stone composition

Stones composed of brushite, calcium oxalate monohydrate, or cystine are particularly hard, as well as homogeneous stones with a high density on NCCT [45, 329]. Percutaneous nephrolithotomy or RIRS and URS are alternatives for removal of large SWL-resistant stones.

Recommendations	Strength rating
Consider the stone composition before deciding on the method of removal, based on patient history, former stone analysis of the patient or Hounsfield unit on unenhanced computed tomography.	Strong
Attempt to dissolve radiolucent stones.	Strong

3.4.8.5 Contraindications of procedures

Contraindications of extracorporeal SWL

There are several contraindications to the use of extracorporeal SWL, including:

- pregnancy, due to the potential effects on the foetus [330];
- bleeding disorders, which should be compensated for at least 24 hours before and 48 hours after treatment [331];
- uncontrolled UTIs;
- severe skeletal malformations and severe obesity, which prevent targeting of the stone;
- arterial aneurysm in the vicinity of the stone [332];
- anatomical obstruction distal to the stone.

Contraindications of URS

Apart from general problems, for example with general anaesthesia or untreated UTIs, URS can be performed in all patients without any specific contraindications.

Contraindications of PNL

Patients receiving anti-coagulant therapy must be monitored carefully pre- and post-operatively. Anti-coagulant therapy must be discontinued before PNL [323]. Other important contraindications include:

- untreated UTI;
- tumour in the presumptive access tract area;
- potential malignant kidney tumour;
- pregnancy (Section 3.4.14.1).

General contraindication for endourological procedures
Endourological interventions do not adversely affect renal function although care must be taken in those with poor pre-operative renal function, diabetes and hypertension [333].

3.4.9 ***Specific stone management of ureteral stones***

3.4.9.1 Conservative treatment/observation

There are only limited data regarding spontaneous stone passage according to stone size [334]. It is estimated that 95% of stones up to 4 mm pass within 40 days [199].

Based on an analysis of available evidence, an exact cut-off size for stones that are likely to pass spontaneously cannot be provided [199].

Spontaneous stone passage was reported for 49% of upper ureteral stones, 58% of mid ureteral stones and 68% of distal ureteral stones. Considering stone size almost 75% of stones < 5 mm and 62% of stones ≥ 5 mm passed spontaneously, with an average time to stone expulsion about seventeen days (range 6-29 days) [335]. The Panel is aware of the fact that spontaneous stone expulsion decreases with increasing stone size and that there are differences between individual patients.

Sexual intercourse has been reported to be beneficial in facilitating stone expulsion in men with ureteral stones, in one MA consisting of three RCTs [336].

3.4.9.2 Pharmacological treatment, medical expulsive therapy

Medical expulsive therapy should only be used in informed patients if active stone removal is not indicated. Treatment should be discontinued if complications develop (infection, refractory pain, deterioration of renal function). In case of known uric acid stones in the distal ureter, a combination of alkalinisation with tamsulosin can increase the frequency of spontaneous passage. For details see sections 3.4.3 and 3.4.4.

3.4.9.3 Indications for active removal of ureteral stones

Indications for active removal of ureteral stones are [199, 334, 337]:

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

3.4.9.4 Selection of procedure for active removal of ureteral stones

Overall, SFRs after URS or SWL for ureteral stones are comparable. However, larger stones achieve earlier stone-free status with URS. Although URS is effective for ureteral calculi, it has greater potential for complications. However, in the current endourological era, the complication rate and morbidity of URS has been significantly reduced [338]. It has been demonstrated that URS is a safe option in obese patients (BMI > 30 kg/m^2) with comparable SFRs and complication rates. However, in morbidly obese patients (BMI > 35 kg/m^2) the overall complication rates double [339].

The Panel performed a systematic review to assess the benefits and harms of URS compared to SWL [340]. Compared with SWL, URS was associated with a significantly greater SFR of up to four weeks, but the difference was not significant at three months in the included studies. Ureteroscopy was associated with fewer retreatments and need for secondary procedures, but with a higher need for adjunctive procedures, greater complication rates and longer hospital stay. Counterbalancing for URS's higher SFRs, SWL is associated with lower morbidity. Clavien-Dindo grade complications were, if reported, less frequent in patients treated with SWL.

Bleeding disorder
Ureteroscopy can be performed in patients with bleeding disorders, with a moderate increase in complications (see also section 3.4.8.2) [323].

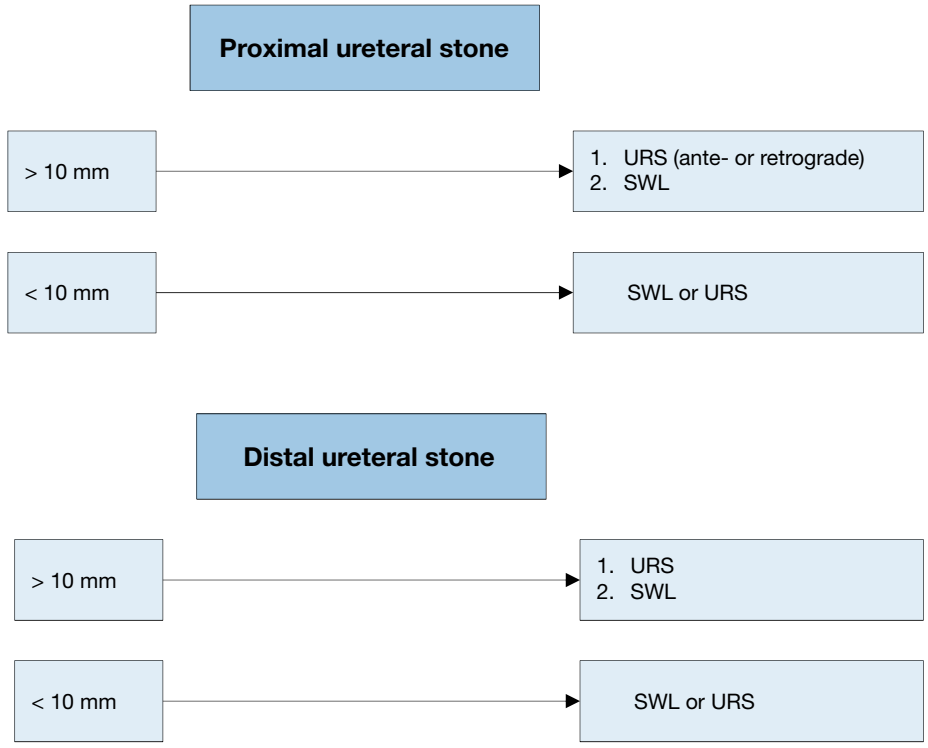
3.4.9.4.1 Summary of evidence and guidelines for selection of procedure for active removal of ureteral stones

Summary of evidence	LE
Observation is feasible in informed patients who develop no complications (infection, refractory pain, deterioration of renal function).	1a
Medical expulsive therapy seems to be efficacious for treating patients with ureteral stones who are amenable to conservative management. The greatest benefit might be among those with > 5 mm (distal) stones.	1a
Compared with SWL, URS was associated with significantly greater SFRs up to four weeks, but the difference was not significant at three months in the included studies.	1a
Ureteroscopy was associated with fewer retreatments and need for secondary procedures, but with a higher need for adjunctive procedures, greater complication rates and longer hospital stay.	1a
In the case of severe obesity, URS is a more promising therapeutic option than SWL.	2b

Recommendations	Strength rating
If active removal is not indicated (section 3.4.9.3) in patients with newly diagnosed small* ureteral stones, observe 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 ureteroscopy (URS) has a better chance of achieving stone-free status with a single procedure.	Strong
Inform patients that URS has higher complication rates when compared to shock wave lithotripsy.	Strong
Use URS as first-line therapy for ureteral (and renal) stones in cases of severe obesity.	Strong

**See stratification data [199].*

Figure 3.1: Treatment algorithm for ureteral stones (if active stone removal is indicated)



SWL = shock wave lithotripsy; URS = Ureteroscopy.

3.4.10 ***Specific stone management of renal stones***

The natural history of small, non-obstructing asymptomatic calculi is not well defined, and the risk of progression is unclear. There is still no consensus on the follow-up duration, timing, and type of intervention. Treatment options are chemolysis or active stone removal.

3.4.10.1 Conservative treatment (observation)

Observation of renal stones, especially in calyces, depends on their natural history (section 3.4.10.3). The recommendations provided are not supported by high-level literature [341]. There is a prospective trial supporting annual observation for asymptomatic inferior calyceal stones, < 10 mm. In case stone growth is detected, the follow-up interval should be lowered. Intervention is advised for growing stones > 5 mm [342]. In a systematic review of patients with asymptomatic renal stones on active surveillance spontaneous stone passage rates varied from 3-29%, symptom development from 7-77%, stone growth from 5-66%, surgical intervention from 7-26% [341].

3.4.10.2 Pharmacological treatment of renal stones

Dissolution of stones through pharmacological treatment is an option for uric acid stones only, but information on the composition of the stone will need to guide the type of treatment selected. See sections 3.4.4. and 3.4.8.4.

3.4.10.3 Indications for active stone removal of renal stones

Indications for the removal of renal stones, include:

- stone growth;
- stones in high-risk patients for stone formation;
- obstruction caused by stones;
- infection;
- symptomatic stones (e.g., pain or haematuria) [343];
- stones > 15 mm;
- stones < 15 mm if observation is not the option of choice;
- patient preference;
- comorbidity;
- social situation of the patient (e.g., profession or travelling);
- choice of treatment.

The risk of a symptomatic episode or need for intervention in patients with asymptomatic renal stones seems to be ~10-25% per year, with a cumulative five-year event probability of 48.5% [342, 344, 345]. A prospective RCT with more than two years clinical follow-up reported no significant difference between SWL and observation when comparing asymptomatic calyceal stones < 15 mm in terms of SFR, symptoms, requirement for additional treatment, quality of life (QoL), renal function, or hospital admission [346]. Although some have recommended prophylaxis for these stones to prevent renal colic, haematuria, infection, or stone growth, conflicting data have been reported [345, 347, 348]. In a follow-up period of almost five years after SWL, two series have demonstrated that up to 25% of patients with small residual fragments needed treatment [208, 349]. Although the question of whether calyceal stones should be treated is still unanswered, stone growth, *de novo* obstruction, associated infection, and acute and/or chronic pain are indications for treatment [343, 350, 351].

3.4.10.4 Selection of procedure for active removal of renal stones

For general recommendations and precautions see section 3.4.8.

3.4.10.4.1 Stones in renal pelvis or upper/middle calyces

Shock wave lithotripsy, PNL and RIRS are available treatment modalities for renal calculi. While PNL efficacy is hardly affected by stone size, the SFRs after SWL or URS are inversely proportional to stone size [352-355]. Shock wave lithotripsy achieves good SFRs for stones up to 20 mm, except for those at the lower pole [354, 356, 357]. Endourology is considered an alternative because of the reduced need for repeated procedures and consequently a shorter time until stone-free status is achieved. Stones > 20 mm should be treated primarily by PNL, because SWL often requires multiple treatments, and is associated with an increased risk of ureteral obstruction (colic or steinstrasse) with a need for adjunctive procedures (Figure 3.2) [197]. Retrograde renal surgery cannot be recommended as first-line treatment for stones > 20 mm in uncomplicated cases as SFRs decrease, and staged procedures will be required [358-360]. However, it may be a first-line option in patients where PNL is not an option or contraindicated.

3.4.10.4.2 Stones in the lower renal pole

The stone clearance rate after SWL seems to be lower for stones in the inferior calyx than for other intra-renal locations. Although the disintegration efficacy of SWL is not limited compared to other locations, the fragments often remain in the calyx and cause recurrent stone formation. The reported SFR of SWL for lower pole calculi is 25-95%. The preferential use of endoscopic procedures is supported by some current reports, even for stones < 1 cm [197, 352, 353, 355, 356, 360-373].

The following can impair successful stone treatment by SWL [363, 374-379]:

- steep infundibular-pelvic angle;
- long calyx;
- long skin-to-stone distance;
- narrow infundibulum;
- shock wave-resistant stones (calcium oxalate monohydrate, brushite, or cystine).

Further anatomical parameters cannot yet be established. Supportive measures such as inversion, vibration or hydration may facilitate stone clearance (See section 3.4.5 ESWL) [194, 196, 380].

If there are negative predictors for SWL, PNL and RIRS might be reasonable alternatives, even for smaller calculi [361]. Retrograde renal surgery seems to have comparable efficacy to SWL [197, 353, 356, 381]. Recent clinical experience has suggested a higher SFR of RIRS compared to SWL, but at the expense of greater invasiveness. Depending on operator skills, stones up to 3 cm can be treated by RIRS [230, 382-384]. However, staged procedures are frequently required.

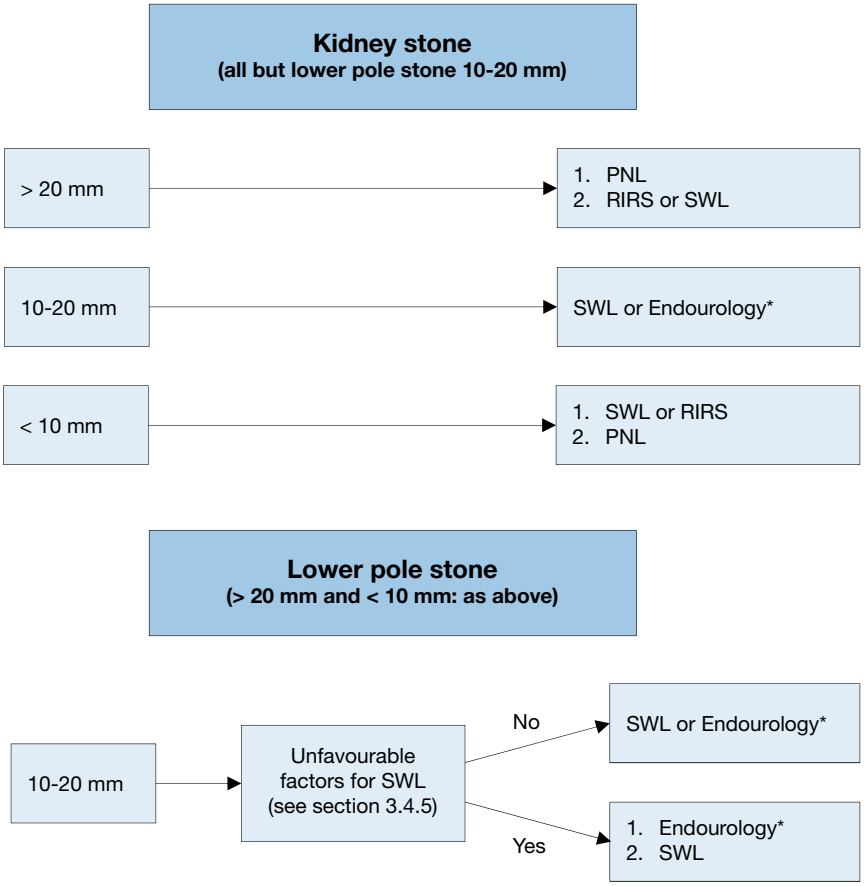
In complex stone cases, open or laparoscopic approaches are possible alternatives although they are infrequently used.

3.4.10.5 Summary of evidence and guidelines for the management of renal stones

Summary of evidence	**LE**
It is still debatable whether renal stones should be treated, or whether annual follow-up is sufficient for asymptomatic calyceal stones that have remained stable for six months.	4
Although the question of whether asymptomatic calyceal stones should be treated is still unanswered, stone growth, *de novo* obstruction, associated infection, and acute and/or chronic pain are indications for treatment.	3
Percutaneous nephrolithotomy is indicated in renal stones > 2 cm as primary option.	1a

Recommendations	**Strength rating**
Follow-up periodically in cases where renal stones are not treated (initially after six months then yearly, evaluating symptoms and stone status, either by ultrasound, kidney-ureter bladder radiography or computed tomography [CT]).	Strong
Offer active treatment for renal stones in case of stone growth, *de novo* obstruction, associated infection, and acute and/or chronic pain.	Weak
Evaluate stone composition before deciding on the method of removal, based on patient history, former stone analysis of the patient or Hounsfield unit (HU) on unenhanced CT. Stones with density > 1,000 HU (and with high homogeneity) on non-contrast-enhanced CT are less likely to be disintegrated by shock wave lithotripsy (SWL).	Strong
Perform percutaneous nephrolithotomy (PNL) as first-line treatment of larger stones > 2 cm.	Strong
Treat larger stones (> 2 cm) with flexible ureteroscopy or SWL, in cases where PNL is not an option. However, in such instances there is a higher risk that a follow-up procedure and placement of a ureteral stent may be needed.	Strong
Perform PNL or retrograde intrarenal surgery for the lower pole, even for stones > 1 cm, as the efficacy of SWL is limited (depending on favourable and unfavourable factors for SWL).	Strong

Figure 3.2: Treatment algorithm for renal stones (if/when active treatment is indicated)



**The term 'Endourology' encompasses all PNL and URS interventions.*
PNL = percutaneous nephrolithotomy; RIRS = retrograde intrarenal surgery; SWL = shock wave lithotripsy; URS = ureteroscopy.

3.4.11 Laparoscopy and open surgery

Advances in SWL and endourological surgery (URS and PNL) have significantly decreased the indications for open or laparoscopic stone surgery [385-390]. There is a consensus that most complex stones, including partial and complete staghorn stones, should be approached primarily with PNL. Additionally, a combined approach with PNL and RIRS may also be an appropriate alternative. However, if percutaneous approaches are not likely to be successful, or if multiple endourological approaches have been performed unsuccessfully; open or laparoscopic surgery may be a valid treatment option [391-397].

Few studies have reported laparoscopic stone removal. These procedures are usually reserved for special cases. When expertise is available, laparoscopic ureterolithotomy can be performed for large proximal ureteral stones as an alternative to URS or SWL [398, 399]. These more invasive procedures have yielded high SFRs and lower auxiliary procedure rates [223, 234, 400]. A recent systematic review showed no difference in the post-operative phase for stented or unstented laparoscopic ureterolithotomy [400].

Laparoscopic pyelolithotomy could be offered for solitary stones > 2 cm located in renal pelvis as an alternative to PNL [401]. In addition, in selected cases with an extrarenal and dilated pelvis, RLP can be considered as an alternative management of staghorn calculi [402].

A few studies with limited numbers of patients have reported using robotic surgery in the treatment of urinary stones [403]. Open surgery should be considered as the last treatment option, after all other possibilities have been explored.

Studies on laparoscopy should be interpreted with caution due to their weak design and low quality of evidence.

3.4.11.1 Summary of evidence and guideline for laparoscopy and open surgery

Recommendation	Strength rating
Offer laparoscopic or open surgical stone removal in rare cases in which shock wave lithotripsy, retrograde or antegrade ureteroscopy and percutaneous nephrolithotomy fail, or are unlikely to be successful.	Strong

*3.4.12 **Steinstrasse***

Steinstrasse is an accumulation of stone fragments or stone gravel in the ureter and may interfere with the passage of urine [404]. Steinstrasse occurs in 4-7% cases of SWL [218], and the major factor in the development of steinstrasse formation is stone size [405].

A major problem of steinstrasse is ureteral obstruction, which may be silent in up to 23% of cases. A MA including eight RCTs (n = 876) suggested a benefit of stenting before SWL in terms of steinstrasse formation, but did not result in a benefit on SFRs or less auxiliary treatments [147]. When steinstrasse is asymptomatic, conservative treatment is an initial option. Medical expulsion therapy increases stone expulsion and reduces the need for endoscopic intervention [406, 407]. Ureteroscopy and SWL are effective in treatment of steinstrasse [220, 408]. In the event of UTI or fever, the urinary system should be decompressed, preferably by percutaneous nephrostomy [120, 122].

3.4.12.1 Summary of evidence and guidelines for steinstrasse

Summary of evidence	LE
Medical expulsion therapy increases the stone expulsion rate of steinstrasse.	1b
Ureteroscopy is effective for the treatment of steinstrasse.	3
Only low-level evidence is available, supporting SWL or URS for the treatment of steinstrasse.	4

Recommendations	Strength rating
Treat steinstrasse associated with urinary tract infection (UTI)/fever preferably with percutaneous nephrostomy.	Weak
Treat steinstrasse when large stone fragments are present with shock wave lithotripsy or ureteroscopy (in absence of signs of UTI).	Weak

*3.4.13 **Management of patients with residual stones***

Following initial treatment with SWL, URS or PNL, residual fragments may remain and require additional intervention [349, 409, 410]. Most of the studies indicate that initial imaging is performed on the first day or the first week after treatment. However, false positive results from dust or residual fragments, that will pass spontaneously without causing any stone-related event, might lead to over-treatment. Therefore, imaging at four weeks seems most appropriate [411-413]. Compared to US, KUB and IVU, NCCT scan has a higher sensitivity to detect small residual fragments after definitive treatment of ureteral or kidney stones [414, 415]. However, more than half of the patients with a residual fragment on NCCT images may not experience a stone-related event [416].

It is clear that NCCT has the highest sensitivity to detect residual fragments; however, this must be balanced against the increased detection of clinically insignificant fragments and the exposure to ionising radiation when compared with KUB and US. In the absence of high-level supporting evidence, the timing of follow-up imaging studies and need for secondary intervention is left to the discretion of the treating physician. Recurrence risk in patients with residual fragments after treatment of infection stones is higher than for other stones [417]. For all stone compositions, 21-59% of patients with residual stones required treatment within five years. Fragments > 5 mm are more likely than smaller ones to require intervention [208, 418, 419]. There is evidence that fragments > 2 mm are more likely to grow, although this is not associated with increased re-intervention rates at one year follow-up [409].

3.4.13.1 Summary of evidence and guideline for management of patients with residual stones

Summary of evidence	LE
To detect residual fragments after SWL, URS or PNL, deferred imaging is more appropriate than immediate imaging post intervention.	3

Recommendation	Strength rating
Perform imaging after shock wave lithotripsy, ureteroscopy or percutaneous antegrade ureteroscopy to determine presence of residual fragments.	Strong

3.4.14 ***Management of specific patient groups***

3.4.14.1 Management of urinary stones and related problems during pregnancy

Clinical management of a pregnant urolithiasis patient is complex and demands close collaboration between patient, radiologist, obstetrician, and urologist. For diagnostic imaging see section 3.3.1.

If spontaneous passage does not occur, or if complications develop (e.g., intractable symptoms, severe hydronephrosis, spontaneous renal fornix rupture [420] or induction of premature labour), placement of a ureteral stent or a percutaneous nephrostomy tube is necessary as it is more effective than conservative treatment for symptom relief [421-423].

Unfortunately, these temporising therapies are often associated with poor tolerance, and they require multiple exchanges during pregnancy, due to the potential for rapid encrustation [424].

Ureteroscopy has become a reasonable alternative in these situations [413, 425]. When compared to temporary ureteral JJ stenting until after delivery, ureteroscopy resulted in fewer needs for stent exchanges, less irritative LUTS and better patient satisfaction [426].

Non-urgent ureteroscopy in pregnant women is best performed during the second trimester by an experienced urologist. Counselling of the patient should include access to neonatal and obstetric services [76].

Although feasible, percutaneous removal of renal stones during pregnancy remains an individual decision and should be performed only in experienced centres [427]. Pregnancy remains an absolute contraindication for SWL.

3.4.14.1.1 Summary of evidence and guideline for the management of urinary stones and related problems during pregnancy

Summary of evidence	LE
Stent insertion seems to be more effective than conservative treatment in the management of symptomatic moderate-to-severe hydronephrosis during pregnancy.	1a
Ureteroscopy is a reasonable alternative to avoid long-term stenting/drainage.	1b
There is a higher tendency for stent encrustation during pregnancy.	3

Recommendation	Strength rating
Treat all uncomplicated cases of urolithiasis in pregnancy conservatively (except when there are clinical indications for intervention).	Strong

3.4.14.2 Management of stones in patients with urinary diversion

Aetiology

Patients with urinary diversion are at high risk for stone formation in the renal collecting system and ureter or in the conduit or continent reservoir [428, 429]. Metabolic factors (hypercalciuria, hyperoxaluria and hypocitraturia), infection with urease-producing bacteria, foreign bodies, mucus secretion, and urinary stasis are responsible for stone formation [430] (section 3.1.3). One study has shown that the risk for recurrent upper tract stones in patients with urinary diversion subjected to PNL was 63% at five years [431].

Management

Smaller upper-tract stones can be treated effectively with SWL [227, 432]. In the majority of cases, endourological techniques are necessary to achieve stone-free status [225]. In individuals with long, tortuous conduits or with

invisible ureter orifices, a retrograde endoscopic approach might be difficult or impossible [433].

For stones in the conduit, a trans-stomal approach can be used to remove all stone material (along with the foreign body) using standard techniques, including intracorporeal lithotripsy and flexible endoscopes. Trans-stomal manipulations in continent urinary diversion must be performed carefully to avoid disturbance of the continence mechanism [434].

Before considering any percutaneous approach in these cases, CT should be undertaken to assess the presence of overlying bowel, which could make this approach unsafe [435], and if present, an open surgical approach should be considered.

Prevention

Recurrence risk is high in these patients [431]. Metabolic evaluation and close follow-up are necessary to obtain the risk parameters for effective long-term prevention. Preventive measures include medical management of metabolic abnormalities, appropriate therapy of urinary infections, and hyperdiuresis or regular irrigation of continent reservoirs [436].

3.4.14.2.1 Summary of evidence and guideline for the management of stones in patients with urinary diversion

Summary of evidence	**LE**
The choice of access depends on the feasibility of orifice identification in the conduit or bowel reservoir. Whenever a retrograde approach is impossible, percutaneous access with antegrade ureteroscopy is the alternative.	4

Recommendation	**Strength rating**
Perform percutaneous lithotomy to remove large renal stones in patients with urinary diversion, as well as for ureteral stones that cannot be accessed via a retrograde approach, or that are not amenable to shock wave lithotripsy.	Strong

3.4.14.3 Management of stones in patients with neurogenic bladder

Aetiology, clinical presentation and diagnosis

Patients with neurogenic bladder develop urinary calculi because of additional risk factors such as bacteriuria, hydronephrosis, VUR, renal scarring and lower urinary tract reconstruction [437]. The most common causes are urinary stasis and infection (section 3.1.3). Indwelling catheters and surgical interposition of bowel segments for treatment of bladder dysfunction both facilitate UTI. Although calculi can form at any level of the urinary tract, they occur more frequently in the bladder; especially if bladder augmentation has been performed [438, 439].

Diagnosis of stones may be difficult and delayed in the absence of clinical symptoms due to sensory impairment and vesico-urethral dysfunction. Difficulties in self-catheterisation should lead to suspicion of bladder calculi. Imaging studies are needed (US, CT) to confirm the clinical diagnosis prior to surgical intervention.

Management

Management of calculi in patients with neurogenic bladder is similar to that described in section 3.3.3. In myelomeningocele patients, latex allergy is common; therefore, appropriate measures need to be taken regardless of the treatment [440]. Any surgery in these patients must be performed under general anaesthesia because of the impossibility of using spinal anaesthesia. Bone deformities often complicate positioning on the operating table [441]. The risk of stone formation after augmentation cystoplasty in immobile patients with sensory impairment can be significantly reduced by irrigation protocols [436].

For efficient long-term stone prevention in patients with neurogenic bladder, correction of the metabolic disorder, appropriate infection control, and restoration of normal storing/voiding function of the bladder are needed.

3.4.14.3.1 Summary of evidence and guideline for the management of stones in patients with neurogenic bladder

Summary of evidence	**LE**
Patients undergoing urinary diversion and/or suffering from neurogenic bladder dysfunction are at risk for recurrent stone formation.	3
In myelomeningocele patients, latex allergy is common.	2

Recommendation	Strength rating
Take appropriate measures regardless of the treatment provided since in myelomeningocele patients latex allergy is common.	Strong

3.4.14.4 Management of stones in patients with transplanted kidneys

Stones in transplanted kidneys can either be transplanted or present *de novo* allograft stones. Usually they are detected by routine US examination, followed by NCCT in cases of unclear diagnosis [442].

Aetiology

Transplant patients depend on their solitary kidney for renal function. Impairment causing urinary stasis/obstruction therefore requires immediate intervention or drainage of the transplanted kidney. Stones in kidney allografts have an incidence of 1% [443]. Risk factors for *de novo* stone formation in these patients are multi-fold:

- Immunosuppression increases the infection risk, resulting in recurrent UTIs.
- Hyper-filtration, excessively alkaline urine, renal tubular acidosis (RTA), and increased serum calcium caused by persistent tertiary hyperparathyroidism [444] are biochemical risk factors.

Management

Selecting the appropriate technique for stone removal in a transplanted kidney is difficult, although management principles are similar to those applied in other single renal units [445-447]. Additional factors such as transplant function, coagulative status, and anatomical obstacles due to the iliacal position of the organ directly influence the surgical strategy.

For large or ureteral stones, careful percutaneous access and subsequent antegrade endoscopy are more favourable. The introduction of small flexible ureteroscopes and the holmium laser has made URS a valid treatment option for transplant calculi; however, one must be aware of potential injury to adjacent organs [446, 448, 449]. Retrograde access to transplanted kidneys is difficult due to the anterior location of the ureteral anastomosis, and ureteral tortuosity [450-452].Treatment of donor stones may be needed pre-transplant and increases the pool available for renal transplants. Post-transplant stone disease may also need treatment to maintain the allograft function. A systematic review evaluating the outcomes of pre- vs. post-transplant URS demonstrated a 100% SFR with an overall 7.5% complication rate, compared to SFR of 60-100% with an overall complication rate of 12.9% for post-transplant URS; most complications were Clavien 1 [453].

3.4.14.4.1 Summary of evidence and guideline for the management of stones in patients with transplanted kidneys

Summary of evidence	LE
Conservative treatment for small asymptomatic stones is only possible under close surveillance and in absolutely compliant patients.	3
Shock wave lithotripsy for small calyceal stones is an option with minimal risk of complication, but localisation of the stone can be challenging and SFRs are poor.	4

Recommendation	Strength rating
Offer patients with transplanted kidneys, any of the contemporary management options, including shock wave lithotripsy, flexible ureteroscopy and percutaneous nephrolithotomy.	Weak

3.4.14.5 Special problems in stone removal

Table 3.11: Special problems in stone removal

Calyceal diverticulum stones	• SWL, PNL [454] (if possible) or RIRS [454, 455]. • Can also be removed using laparoscopic retroperitoneal surgery [456, 457]. • Patients may become asymptomatic due to stone disintegration (SWL), whilst well-disintegrated stone material remains in the original position due to narrow calyceal neck.
Horseshoe kidneys	• Can be treated in line with the options described above [458]. • Passage of fragments after SWL might be poor. • Acceptable SFRs (up to 76%) with low major complication rates (2.4%) can be achieved with flexible ureteroscopy [459, 460].
Stones in pelvic kidneys	• SWL, RIRS, PNL or laparoscopic surgery [461].

Stones formed in a continent reservoir	• Each stone must be considered and treated individually.
Patients with obstruction of the UPJ	• When outflow abnormality requires correction, stones can be removed by PNL together with percutaneous endopyelotomy or open/laparoscopic reconstructive surgery. • URS together with endopyelotomy with Ho:YAG laser. • Incision with an Acucise® balloon catheter might be considered, provided the stones can be prevented from falling into the pelvic-ureteral incision [462-465]. • Open surgery with correction of the UPJ obstruction (pyeloplasty) and stone removal is a feasible option [466].

*3.4.15 **Management of stones in children***

The true incidence of nephrolithiasis in children remains unclear due to the global lack of large epidemiological studies. Data derived from nationwide epidemiological studies, studies performed in different counties worldwide [467] and large-scale databases [468, 469] indicate that the incidence and prevalence of paediatric urinary stone disease has increased over the last few decades. Although boys are most commonly affected in the first decade of life [470] the greatest increase in incidence has been seen in older female adolescences [467].

Stone composition is similar in children as in adults, with a predominance of calcium oxalate stones. Compared to historical data, metabolic abnormalities responsible for stone formation are less commonly identified in children nowadays [471-473]. Hypocitraturia, low urine volume and hypercalciuria predominate [85, 471-473]. Age may affect the predominant metabolic abnormality with hypercalciuria and hypocitraturia being the most common disorder present in children < 10 and > 10 years old, respectively [473]. Genetic or systemic diseases (e.g., cystinuria or nephrocalcinosis) contributing to stone formation are relatively frequent in children accounting for less than 17% of the identifying causes [471, 474]. The role of diet remains unclear in children, although there is some evidence that children are drinking less water and taking greater daily amounts of sodium than is recommended [475-477].

For diagnostic procedures see section 3.3.3.2, for acute decompression see section 3.4.2. and for metabolic evaluation see chapter 4.

3.4.15.1 Clinical presentation

Children with urinary stones can be asymptomatic or present with non-specific symptoms that necessitate a high index of suspicion for proper diagnosis. Symptoms are age-dependent with infants presenting with crying, irritability and vomiting in 40% of cases [478] while in older children flank pain, micro or gross haematuria and recurrent UTIs are more common [479].

3.4.15.2 Conservative management

There is a lack of evidence on conservative management of paediatric stones with evidence for ureteric calculi coming from the placebo arms of medical expulsive trials, while evidence for renal stones comes from small cohort studies, either on primary stones [480, 481] or residual fragments remained after SWL, RIRS or PNL [482]. Expectant management for single, asymptomatic lower-pole renal stones could be the initial approach with increased odds of stone passage, especially in patients with non-struvite, non-cystine stones < 7 mm, with no anatomic abnormalities [480]. Intervention may be needed for stones located elsewhere independently of their size [480-482].

3.4.15.3 Medical expulsive therapy in children

There are limited studies on MET as off-label expulsive therapy for children with stones which show conflicting outcomes. A recent MA of five trials showed that adrenergic α-antagonists (tamsulosin 0.2-0.4 mg/day and doxazosin 0.03 mg/kg/day) are effective for MET increasing SFR compared to control (OR = 2.7, p = 0.001) without significantly increasing the treatment-emergent adverse events (OR = 2.01, p = 0.17) [483]. Similarly, an updated systematic review of six placebo-controlled studies showed that α-blockers might increase SFR of distal ureteric stones (RR: 1.34, 95% CI: 1.16 - 1.54) [484]. Due to study limitations and very serious imprecision, no conclusion could be drawn regarding the effect of MET on hospital stay, pain episodes or secondary procedures for residual fragments after definitive stone treatment [484].

3.4.15.4 Extracorporeal shock wave lithotripsy

Shock wave lithotripsy is still the first-line treatment for most ureteral stones in children. However, it is less likely to be successful for stones > 10 mm in diameter, impacted stones, calcium oxalate monohydrate or cystine stones, or for stones in children with unfavourable anatomy and in whom localisation is difficult [485].

Studies on extracorporeal SWL in children suggest an overall SFR of 70-90%, retreatment rate of 4-50% and need for auxiliary procedures in 4-12.5% of cases [486-490]. A MA of fourteen studies reporting on 1,842 paediatric patients treated with SWL found significantly higher SFR for stones < 10 mm than for stones > 10 mm and higher retreatment rates as the stone size increased [485]. For best clinical practice see section 3.4.5. A recent MA on slow SWL vs. rapid SWL for renal stones revealed very low-quality evidence about the effects of SWL on SFRs, serious adverse events or complications of treatment and secondary procedures for residual fragments [484]. Shock wave lithotripsy is well tolerated; however, good treatment outcomes are more likely to require the administration of general anaesthesia to children. With improvements in modern (second and third generation) lithotripters, successful treatment using intravenous sedation, patient-controlled analgesia or no medication at all has been increasingly performed in a select population of older, co-operative children [491].

Based on the results of a recent MA which compared SWL to dissolution therapy for intra-renal stones, and SWL to ureteroscopy with holmium laser or pneumatic lithotripsy for renal and distal ureteric stones, no firm conclusions can be drawn about the effects of SWL on SFR, serious adverse events or complications of treatment and secondary procedures for residual fragments [484]. When SWL was compared to mini-percutaneous nephrolithotomy for lower pole renal stones 1-2 cm in size SWL resulted in lower SFRs (RR: 0.88, 95% CI: 0.80 - 0.97; moderate-quality evidence) and higher rates of secondary procedures (RR: 2.50, 95% CI: 1.01 - 6.20; low-quality evidence); however, SWL showed less severe adverse events (RR: 0.13, 95% CI: 0.02 - 0.98; low-quality evidence) [492].

3.4.15.5 Endourological procedures

Rigid/semi-rigid ureteroscopy

In recent years ureteroscopy is increasingly used in children with ureteral stones [493]. Ureteroscopy proved to be effective with SFR of 81-98% [494-496], retreatment rates of 6.3%-10% [497] and complication rates of 1.9-23% [494-496, 498]. Similar to adults, routine stenting is not necessary before URS. Pre-stenting may facilitate URS, increase SFR and decrease complication rates [499, 500].

Flexible ureteroscopy/retrograde intrarenal surgery

Retrograde intra-renal surgery with flexible ureteroscopes (FURS) has become an efficacious treatment modality for paediatric renal stones. Recent studies report SFRs of 76-100%, retreatment rates of 0-19% and complication rates of 0-28% [501-504]. Younger age, cystine composition [505], large stone diameter [504] and lack of pre-stenting predispose to FURS failure in children [499].

Although high-level evidence is lacking to support a strong recommendation [484], FURS may be a particularly effective treatment option for lower calyceal stones in the presence of unfavourable factors for SWL [496, 502, 506].

For large and complex kidney stones RIRS has a significantly lower SFR compared to PNL (71% vs. 95%), but is associated with less radiation exposure, lower complication rates and a shorter hospital stay [507]. Similarly, retrospectively data indicate that RIRS may achieve lower SFRs compared to minor micropercutaneous surgery in favour of shorter operative time, shorter fluoroscopy time, and less hospitalisation time [508, 509]. A recently published MA confirmed these results [510].

Percutaneous nephrolithotomy

Indications for PNL in children are similar to those in adults, and include renal stones > 2 cm, or smaller stones resistant to SWL and ureteroscopic treatment. Reported SFRs with paediatric PNL are 71.4-95% after a single session [507-509, 511, 512] with an overall complication rate of 20% [513]. High degree of hydronephrosis, increased number of tracts and operative time [514] and large tract size [512, 515-517] are associated with increased blood loss. Child age [516] and stone burden [512] predispose to the use of larger instruments during PNL in children. Miniaturisation of equipment increases the opportunity to perform tubeless PNL in appropriately selected children, which can reduce the length of hospital stay and post-operative pain [518, 519].

Concerns have been raised regarding possible adverse effects of PNL on the renal parenchyma of the developing child. However, focal damage is only reported in 5% of cases [520]. Using pre- and post-PNL dimercaptosuccinic acid (DMSA) scans, Cicekbilek *et al*., demonstrated that PNL tracts between 12-24 Charrière in size did not cause significant harm to paediatric kidneys [511].

3.4.15.6 Open and laparoscopic/robot-assisted stone surgery

With the advances in ESWL, PNL and RIRS, very few cases of paediatric urolithiasis require open surgery. Data extracted from the National Inpatient Sample (NIS) databases for 2001-2014 showed that in the USA incisional procedures (mainly nephrolithotomy, pyelolithotomy and ureterotomy) were performed in 2.6% of hospitalised patients (52% aged 15-17 years) who required surgical intervention for urinary stones [521]. Laparoscopy

for the management of paediatric renal and ureteric stones is a safe and effective procedure when specific indications are followed. Stone free rates of 100% were reported when laparoscopic pyelolithotomy was applied for a > 1 cm single stone located in an extra-renal pelvis [522], or when laparoscopic ureterolithotomy was applied to impacted ureteric stones ≥ 1.5 cm, or to ureteric stones that were refractory to SWL or URS [523]. There are extremely limited data available on efficacy and complications of robot-assisted laparoscopic management of paediatric urolithiasis [524].

3.4.15.7 Special considerations on recurrence prevention

All paediatric stone formers need metabolic evaluation and recurrence prevention with respect to the detected stone type. Children are in the high-risk group for stone recurrence (See chapter 4).

3.4.15.8 Summary of evidence and guidelines for the management of stones in children

Summary of evidence	LE
In children, the indications for SWL, URS and PNL are similar to those in adults.	1b
Children with renal stones of a diameter up to 20 mm (~300 mm^2) are ideal candidates for SWL.	1b
Ureteroscopy has become the treatment of choice for larger distal ureteral stones in children.	1a
In children, the indications for PNL are similar to those in adults.	1a

Recommendations	Strength rating
Offer children with single ureteral stones > 10 mm shock wave lithotripsy (SWL) if localisation is possible or ureteroscopy as first-line option.	Strong
Ureteroscopy is a feasible alternative for ureteral stones not amenable to SWL.	Strong
Offer children with renal stones with a diameter of up to 20 mm (~300 mm^2) SWL.	Strong
Offer children with renal pelvic or calyceal stones with a diameter > 20 mm (~300 mm^2) percutaneous nephrolithotomy.	Strong
Retrograde renal surgery is a feasible alternative for renal stones smaller than 20 mm in all locations.	Weak

3.5 Radiation exposure and protection during endourology

The diagnosis and treatment of nephrolithiasis is associated with high levels of ionising radiation exposure to patients [525, 526]. Currently, there are no studies estimating the lifetime radiation exposure of stone formers or the subsequent risk of malignancy development. The radiation exposure of endourologists has been extensively studied. Still, there are no studies assessing the risk of radiation induced malignancies in urologists or operating theatre staff members [527-529].

Current evidence from atomic bomb patients [530, 531], retrospective epidemiological data on medical exposure [532, 533] and modelling studies [534, 535] suggest an age and dose dependent risk of secondary malignancy from ionising radiation.

The International Commission on Radiological Protection (ICRP) recommends a maximum annual occupational exposure of 50mSv [536]. However, the risk of radiation induced malignancy follows a stochastic model having no known safe threshold of exposure. Taking this into consideration as well as the length of a urologists career the upper limit of 50mSv is still highly concerning.

Table 3.12 shows the EAU Urolithiasis guidelines panel recommended protection methods to reduce radiation exposure to patients, surgical, anaesthesiologic and nursing staff.

Table 3.12 Radiation protection measures

• Limit studies or intervention involving radiation exposure to those that are strictly medically necessary.
• Implement a patient electronic record of medical imaging.
• Make use of imaging studies with lower radiation doses (US, KUB, digital tomosynthesis, low-dose and ultra-low dose CT scan).
• Create and follow a precise radiation exposure protection protocol in your department.
• Act in accordance with the as low as reasonably achievable (ALARA) principle.
• Measure and report fluoroscopy time to the operative surgeon (use dosimeters and perform monthly calculations).

• Technical measures to reduce radiation exposure include: ■ Reducing fluoroscopy time; ■ Limiting time adjacent to patient; ■ Using low-dose radiation; ■ Irradiating only to observe motion; ■ Intra-operative use of pulsed fluoroscopy; ■ Reduced fluoroscopy pulse rate; ■ Collimated fields; ■ Avoid digital image acquisition and rely on last image hold and instant replay technology.
• Use radiation protection instruments (chest, pelvic and thyroid shields, lead or lead-free gloves, protective glasses, lead protection under the operating table between the X-ray source and the surgeon).
• The radiation protection instruments must be cared for appropriately as any damage decreases effectiveness and increases exposure risk. They should be monitored and measured regularly to ensure integrity.
• Proper surgeon and operating room setup should be observed (follow the inverse square law, use the X-ray source underneath the patient's body, decrease the X-ray source to patient distance, reduce magnification, avoid field overlap by not turning the C-arm in extreme angles, operate in the standing rather than the seated position).

Availability of fluoroscopy is mandatory for endourological procedures. There is an increasing interest on fluoroless and fluoroscopy-free operations in urology. Several RCTs have been published showing a good outcome in means of stone-free and complication rates [176, 289, 537-539]. These trials have been limited to non-complex cases and they were not sufficiently powered to show non-inferiority of fluoroscopy in PNL [289, 527] or superiority of US in URS [540, 541]

4. METABOLIC EVALUATION AND RECURRENCE PREVENTION

4.1 General metabolic considerations for patient work-up

4.1.1 ***Evaluation of patient risk***

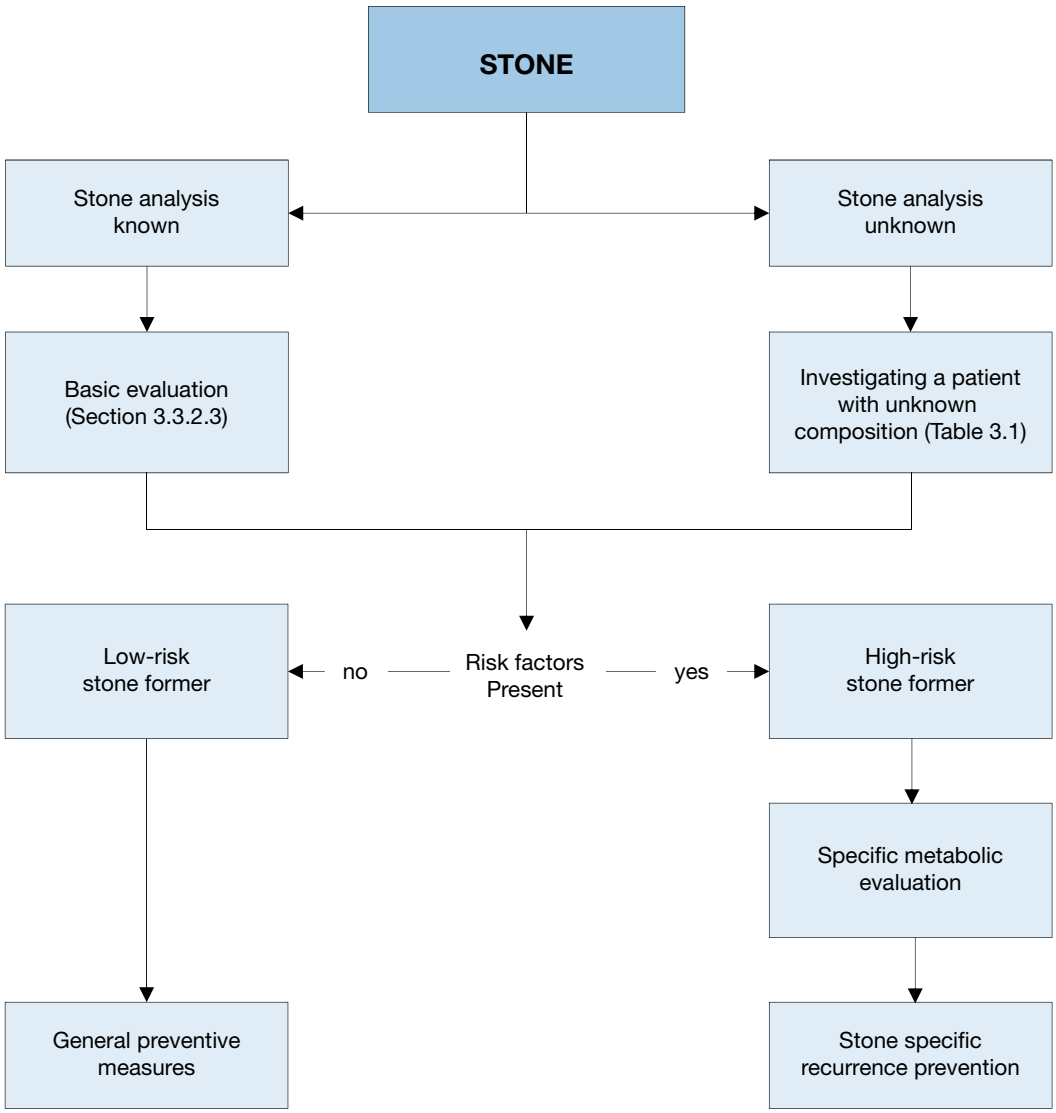
After stone passage, every patient should be assigned to a low- or high-risk group for stone formation (Figure 4.1). For correct classification, two items are mandatory:

- reliable stone analysis by infrared spectroscopy or X-ray diffraction;
- basic analysis (section 3.3.2).

Only high-risk stone formers require specific metabolic evaluation. Stone type is the deciding factor for further diagnostic tests. The different stone types include:

- calcium oxalate;
- calcium phosphate;
- uric acid;
- ammonium urate;
- struvite (and infection stones);
- cystine;
- xanthine;
- 2,8-Dihydroxyadenine;
- drug stones;
- stones of unknown composition.

Figure 4.1: Assignment of patients to low- or high-risk groups for stone formation



4.1.2 Urine sampling

Specific metabolic evaluation requires collection of two consecutive 24-hour urine samples [542, 543]. The collecting bottles should be prepared with 5% thymol in isopropanol or stored at < 8°C during collection to prevent the risk of spontaneous crystallisation in the urine. Pre-analytical errors can be minimised by carrying out urinalysis immediately after collection. Alternatively, boric acid (10 g powder per urine container) can also be used. The collecting method should be chosen in close cooperation with the laboratory. Urine pH should be assessed during collection of freshly voided urine at different times throughout the day using sensitive pH-dipsticks or a pH-meter [25, 544, 545].

Spot urine samples are an alternative method of sampling, particularly when 24-hour's urine collection is difficult, for example, in non-toilet trained children [546]. Spot urine studies normally link the excretion rates to creatinine [547], but these are of limited use because the results may vary with collection time and patients' sex, body weight and age.

4.1.3 Timing of specific metabolic work-up

For the initial 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 twenty days [548]. Follow-up studies are necessary in patients taking medication for recurrence prevention [549]. The first follow-up 24-hour urine measurement is suggested eight to twelve weeks after starting pharmacological prevention of stone recurrence. This enables drug dosage to be adjusted if urinary risk factors have not normalised, with further 24-hour urine measurements, if necessary. Once urinary parameters have been normalised, it is sufficient to perform 24-hour urine evaluation every twelve months. On this issue the Panel realise that there is only very limited published evidence.

4.1.4 Reference ranges of laboratory values

Tables 4.1-4.4 provide the internationally accepted reference ranges for the different laboratory values in serum and urine.

Table 4.1: Normal laboratory values for blood parameters in adults [549, 550]

Blood parameter	Reference range	
Creatinine	20-100 µmol/L	
Sodium	135-145 mmol/L	
Potassium	3.5-5.5 mmol/L	
Calcium	2.0-2.5 mmol/L (total calcium)	
	1.12-1.32 mmol/L (ionised calcium)	
Uric acid	119-380 µmol/L	
Chloride	98-112 mmol/L	
Phosphate	0.81-1.29 mmol/L	
Blood gas analysis	pH	7.35-7.45
	pO_2	80-90 mmHg
	pCO_2	35-45 mmHg
	HCO_3	22-26 mmol/L
	BE	BE ± 2 mmol/L

BE = base excess (loss of buffer base to neutralise acid); HCO_3 = bicarbonate; pCO_2 = partial pressure of carbon dioxide; pO_2 = partial pressure of oxygen.

4.1.5 Risk indices and additional diagnostic tools

Several risk indices have been developed to describe the crystallisation risk for calcium oxalate or calcium phosphate in urine [551-554]. However, clinical validation of these risk indices for recurrence prediction or therapy improvement is ongoing.

Table 4.2: Normal laboratory values for urinary parameters in adults

Urinary Parameters	Reference ranges and limits for medical attention
pH	Constantly > 5.8 (suspicious of renal tubular acidosis)
	Constantly > 7.0 (suspicious of infection)
	Constantly < 5.8 (suspicious of acidic arrest)
Specific weight	Specific weight > 1.010
Creatinine	7-13 mmol/day (females), 13-18 mmol/day (males)
Calcium	> 5.0 mmol/day (see Fig. 4.2)
	> 8.0 mmol/day (see Fig. 4.2)
Oxalate	> 0.5 mmol/day (suspicious of enteric hyperoxaluria)
	> 1.0 mmol/day (suspicious of primary hyperoxaluria)
Uric acid	> 4.0 mmol/day (females), 5 mmol/day (males)
Citrate	< 2.5 mmol/day
Magnesium	< 3.0 mmol/day
Inorganic phosphate	> 35 mmol/day
Ammonium	> 50 mmol/day
Cystine	> 0.8 mmol/day

Table 4.3: Normal values for spot urine samples: creatinine ratios (solute/creatinine) in children [555]

Parameter/Patient age	Ratio of solute to creatinine	Units
Calcium	**mol/mol**	**mg/mg**
< 12 months	< 2.0	0.81
1-3 years	< 1.5	0.53
1-5 years	< 1.1	0.39
5-7 years	< 0.8	0.28
> 7 years	< 0.6	0.21

Oxalate	**mol/mol**	**mg/mg**
0-6 months	< 325-360	288-260
7-24 months	< 132-174	110-139
2-5 years	< 98-101	80
5-14 years	< 70-82	60-65
> 16 years	< 40	32
Citrate	**mol/mol**	**g/g**
0-5 years	> 0.25	0.42
> 5 years	> 0.15	0.25
Magnesium*	**mol/mol**	**g/g**
All age groups	> 0.63	> 0.13
Uric acid		
> 2 years	< 0.56 mg/dL (33 µmol/L) per GFR (ratio x plasma creatinine)	

** There is low-level evidence regarding the importance of magnesium.*

Table 4.4: Solute excretion in 24-hour urine samples in children [556, 557]*****

Calcium/24 hour	**Citrate/24 hour**		**Cystine/24 hour**		**Oxalate/24 hour**		**Urate/24 hour**	
All age groups	Boys	Girls	< 10 years	> 10 years	All age groups	< 1 year	1-5 years	> 5 years
< 0.1 mmol/kg/24 h	> 1.9 mmol/1.73 m^2/24 h	> 1.6 mmol/1.73 m^2/24 h	< 55 µmol/1.73 m^2/24 h	< 200 µmol/1.73 m^2/24 h	< 0.5 mmol/1.73 m^2/24 h	< 70 µmol/kg/24 h	< 65 mµmol/kg/24 h	< 55 µmol/kg/24 h
< 4 mg/kg/24 h	> 365 mg/1.73 m^2/24 h	> 310 mg/1.73 m^2/24 h	< 13 mg/1.73 m^2/24 h	< 48 mg/1.73 m^2/24 h	< 45 mg /1.73 m^2/24 h	< 13 mg/kg/24 h	< 11 mg/kg/24 h	< 9.3 mg/kg/24 h

4.2 General considerations for recurrence prevention

All stone formers, independent of their individual risk, should follow the preventive measures in Table 4.5. The main focus is normalisation of dietary habits and lifestyle risks. Stone formers at high risk need specific prophylaxis for recurrence, which is usually pharmacological treatment based on stone analysis and urinary risk profile.

Table 4.5: General preventive measures

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: < 1,010 g/day
Nutritional advice for a balanced diet	Balanced diet*
	Rich in vegetables 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: Retain a normal BMI level
	Adequate physical activity
	Balancing of excessive fluid loss

Caution: Protein requirements are age dependent; therefore, protein restriction in childhood should be handled carefully.

** Avoid excessive consumption of vitamin supplements.*

*4.2.1 **Fluid intake***

An inverse relationship between high fluid intake and stone formation has been repeatedly demonstrated [556-559]. The effect of fruit juices is mainly determined by the presence of citrate or bicarbonate [560]. If hydrogen ions are present, the net result is neutralisation. However, if potassium is present, both pH and citrate are increased [561, 562]. One large moderate quality RCT randomly assigned men with more than one past renal stone of any type and soft drink consumption of at least 160 mL/day to reduced soft drink intake or no treatment. Although the intervention significantly reduced the risk for symptomatic recurrent stones (RR: 0.83; CI: 0.71-0.98), the level of evidence for this outcome is low because results were from only one trial [563]. An

analysis on the three Channing's cohorts (194,095 participants) over a median follow-up of more than eight years has shown that consumption of sugar-sweetened soda and punch is associated with a higher risk of stone formation, whereas consumption of coffee, tea, beer, wine, and orange juice is associated with a lower risk [564].

*4.2.2 **Diet***

A common-sense approach to diet should be taken, that is, a mixed, balanced diet with contributions from all food groups, without any excesses [557, 565, 566].

Fruit, vegetables and fibre: Fruit and vegetable intake should be encouraged because of the beneficial effects of fibre, although the role of the latter in preventing stone recurrences is debatable [567-570]. The alkaline content of a vegetarian diet also increases urinary pH.

Oxalate: Excessive intake of oxalate-rich products should be limited or avoided to prevent high oxalate load [571], particularly in patients who have high oxalate excretion.

Vitamin C: Although vitamin C is a precursor of oxalate, its role as a risk factor in calcium oxalate stone formation remains controversial [572]. However, it seems wise to advise calcium oxalate stone formers to avoid excessive intake.

Animal protein: Animal protein should not be consumed in excess [573, 574] and limited to 0.8-1.0 g/kg body weight. Excessive consumption of animal protein has several effects that favour stone formation, including hypocitraturia, low urine pH, hyperoxaluria and hyperuricosuria.

Calcium intake: Calcium should not be restricted, unless there are strong reasons for doing so, due to the inverse relationship between dietary calcium and stone formation [568, 575]. The daily requirement for calcium is 1,000 to 1,200 mg [25]. Calcium supplements are not recommended except in enteric hyperoxaluria, when additional calcium should be taken with meals to bind intestinal oxalate [557, 571, 573, 576]. Older adults who do not have a history of renal stones but who take calcium supplements should ensure adequate fluid intake since it may prevent increases in urine calcium concentration, and thereby reduce or eliminate any increased risk of renal stones formation associated with calcium supplement use [577].

Sodium: Daily sodium (NaCl) intake should not exceed 3-5 g [25]. High intake adversely affects urine composition:

- calcium excretion is increased by reduced tubular re-absorption;
- urinary citrate is reduced due to loss of bicarbonate;
- increased risk of sodium urate crystal formation.

Calcium stone formation can be reduced by restricting sodium and animal protein [573, 574]. A positive correlation between sodium consumption and risk of first-time stone formation has been confirmed only in women [575]. There have been no prospective clinical trials on the role of sodium restriction as an independent variable in reducing the risk of stone formation.

Urate: Intake of purine-rich food should be restricted in patients with hyperuricosuric calcium oxalate [578, 579] and uric acid stones. Intake should not exceed 500 mg/day [25].

*4.2.3 **Lifestyle***

Lifestyle factors may influence the risk of stone formation, for example, obesity [580] and arterial hypertension [581, 582].

*4.2.4 **Summary of evidence and guideline for recurrence prevention***

Summary of evidence	**LE**
Increasing fluid intake reduces the risk of stone recurrence.	1a

Recommendation	**Strength rating**
Advise patients that a generous fluid intake is to be maintained, allowing for a 24-hour urine volume > 2.5 L.	Strong

4.3 Stone-specific metabolic evaluation and pharmacological recurrence prevention

*4.3.1 **Introduction***

Pharmacological treatment is necessary in patients at high risk for stone formation. The ideal drug should halt stone formation, have no side effects, and be easy to administer. Each of these aspects is important to achieve good compliance. Table 4.6 highlights the most important characteristics of commonly used medication.

Table 4.6: Pharmacological substances used for stone prevention - characteristics, specifics and dosage

Agent	Rationale	Dose	Specifics and side effects	Stone type	Ref
Alkaline citrates	Alkalinisation Hypocitraturia Inhibition of calcium oxalate crystallisation	5-12 g/d (14-36 mmol/d) Children: 0.1-0.15 g/kg/d	Daily dose for alkalinisation depends on urine pH.	Calcium oxalate Uric acid Cystine	[583-588]
Allopurinol	Hyperuricosuria Hyperuricaemia	100-300 mg/d Children: 1-3 mg/kg/d	100 mg in isolated hyperuricosuria. Renal insufficiency demands dose correction. Allergies from trivial to very severe forms, xanthine stone formation.	Calcium oxalate Uric acid Ammonium urate 2,8-Dihydroxyadenine	[577, 589-592]
Calcium	Enteric hyperoxaluria	Up to 2,000 mg/d depending on oxalate excretion	Intake 30 min before meals.	Calcium oxalate	[573, 575, 576]
Captopril	Cystinuria Active decrease of urinary cystine levels	75-150 mg	Second-line option due to significant side effects of tiopronin.	Cystine	[593, 594]
Febuxostat	Hyperuricosuria Hyperuricaemia	80-120 mg/d	Acute gout contraindicated, pregnancy, xanthine stone formation.	Calcium oxalate Uric acid	[595, 596]
L-Methionine	Acidification	600-1,500 mg/d	Hypercalciuria, bone demineralisation, systemic acidosis. No long-term therapy.	Infection stones Ammonium urate Calcium phosphate	[583, 597]
Magnesium	Isolated hypomagnesiuria Enteric hyperoxaluria	200-400 mg/d Children: 6 mg/kg/d	Renal insufficiency demands dose correction. Diarrhoea, chronic alkali losses, hypocitraturia.	Calcium oxalate	[598, 599] (Low level of evidence)
Sodium bicarbonate	Alkalinisation Hypocitraturia	4.5 g/d	N/A	Calcium oxalate Uric acid, Cystine	[600]
Pyridoxine	Primary hyperoxaluria	Initial dose 5 mg/kg/d Max. 20 mg/kg/d	Polyneuropathia	Calcium oxalate	[601]
Thiazide (Hydrochlorothiazide*)	Hypercalciuria	25-50 mg/d Children: 0.5-1 mg/kg/d	Risk for hypotonic blood pressure, diabetes, hyperuricaemia, hypokalaemia, followed by intracellular acidosis and hypocitraturia.	Calcium oxalate Calcium phosphate	[579, 581-609]

Tiopronin	Cystinuria Active decrease of urinary cystine levels	Initial dose 800 mg/d Avg. 2,000 mg/d** Children: Initial dose in patients > 20kg is 15 mg/kg/day. Avoid dosages > 50mg/kg/day	Risk for tachyphylaxis and proteinuria.	Cystine	[610-613]

** Patients on hydrochlorothiazides should be advised to get their skin checked on a regular basis as they have a higher risk of developing a non-melanoma skin cancer (NMSC). In patients with history of NMSC the indication for the intake of hydrochlorothiazides should be thoroughly reviewed [614, 615].*

*** No information is available on maximum dose and patients may be initiated on a very low dose if they have had previously had reactions to tiopronin or penicillamine. For all patients, dosage should be titrated according to frequency of stone episodes, side effects and renal function under expert supervision with close monitoring.*

4.4 Calcium oxalate stones

The criteria for identification of calcium oxalate stone formers with high recurrence risk are listed in section 3.1.3.

*4.4.1 **Diagnosis***

Blood analysis requires measurement of creatinine, sodium, potassium, chloride, ionised calcium (or total calcium + albumin), phosphate, uric acid; and, in the case of increased calcium levels, parathyroid hormone (PTH) and vitamin D. Urinalysis requires measurement of urine volume, urine pH profile, specific weight, calcium, oxalate, uric acid, citrate, sodium and magnesium. Figure 4.2 summarises the diagnostic steps for calcium oxalate stones.

*4.4.2 **Interpretation of results and aetiology***

The most common metabolic abnormalities associated with calcium stone formation are hypercalciuria, which affects 30-60% of adult stone formers, and hyperoxaluria (26-67%), followed by hyperuricosuria (15-46%), hypomagnesuria (7-23%), and hypocitraturia (5-29%). However, ranges tend to differ based on ethnicity [616].

- Elevated levels of ionised calcium in serum (or total calcium and albumin) require assessment of intact PTH to confirm or exclude suspected hyperparathyroidism (HPT).
- “Acidic arrest” (circadian urine pH constantly < 5.8) may promote co-crystallisation of uric acid and calcium oxalate.
- Similarly, increased uric acid excretion (> 4 mmol/day in adults or > 12 mg/kg/day in children) can act as a promoter.
- Urine pH levels constantly > 5.8 in the day profile may indicate RTA, provided UTI has been excluded. An ammonium chloride loading test confirms RTA and identifies RTA subtype (section 4.6.5).
- Hypercalciuria may be associated with normocalcemia (idiopathic hypercalciuria, or granulomatous diseases) or hypercalcaemia (hyperparathyroidism, granulomatous diseases, vitamin D excess, or malignancy).
- Hypocitraturia (male < 1.7 mmol/day, female < 1.9 mmol/day) may be idiopathic or secondary to metabolic acidosis or hypokalaemia.
- Oxalate excretion > 0.5 mmol/day in adults (> 0.37 mmol/1.73 m^2/day in children) confirms hyperoxaluria.
    - o primary hyperoxaluria (oxalate excretion mostly > 1 mmol/day), appears in three genetically determined forms;
    - o secondary hyperoxaluria (oxalate excretion > 0.5 mmol/day, usually < 1 mmol/day), occurs due to intestinal hyperabsorption of oxalate or extreme dietary oxalate intake;
    - o mild hyperoxaluria (oxalate excretion 0.45-0.85 mmol/day), commonly found in idiopathic calcium oxalate stone formers.
- Hypomagnesuria (< 3.0 mmol/day) may be related to poor dietary intake or to reduced intestinal absorption (chronic diarrhoea).

Figure 4.2: Diagnostic algorithm for calcium oxalate stones

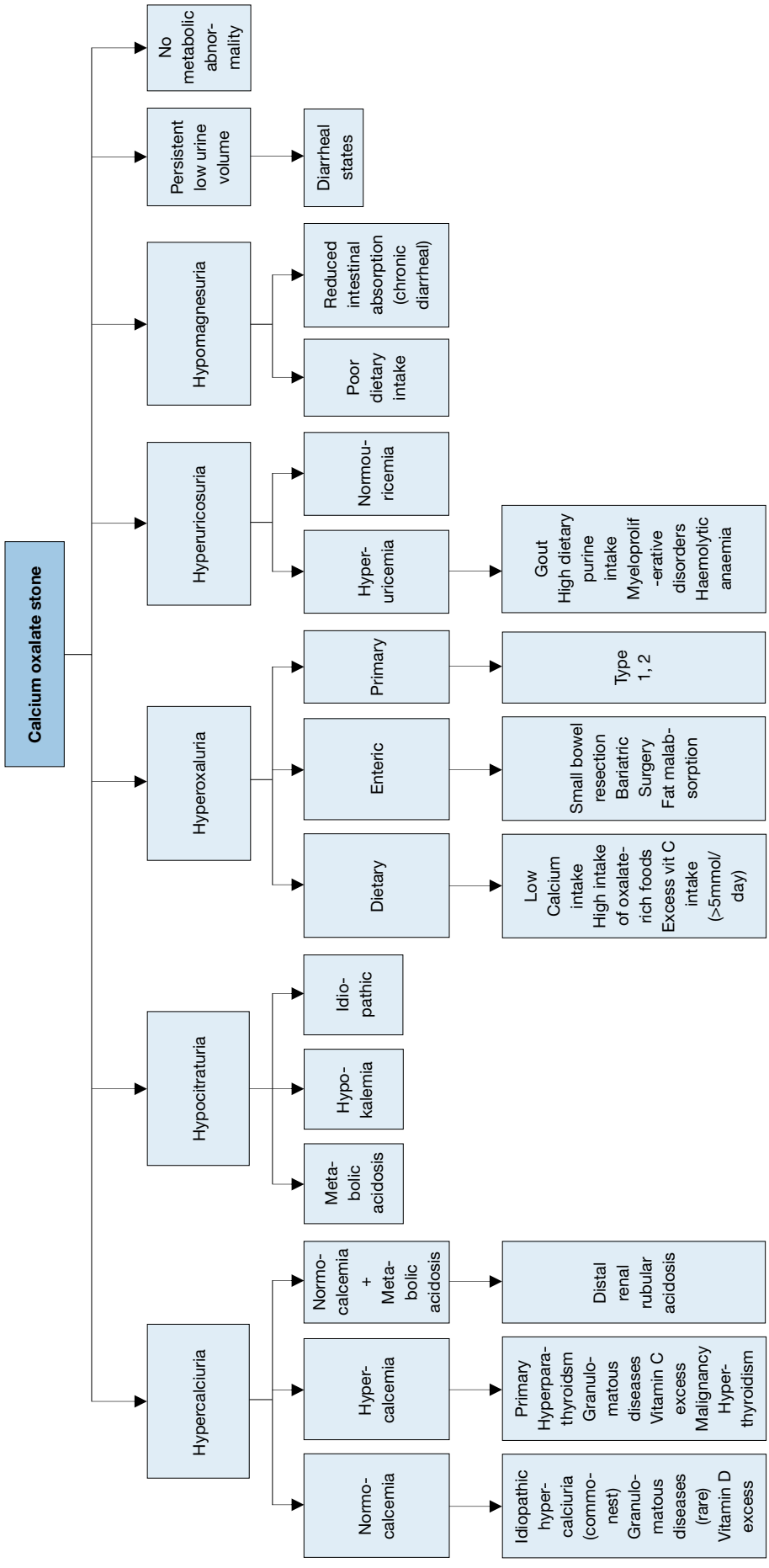
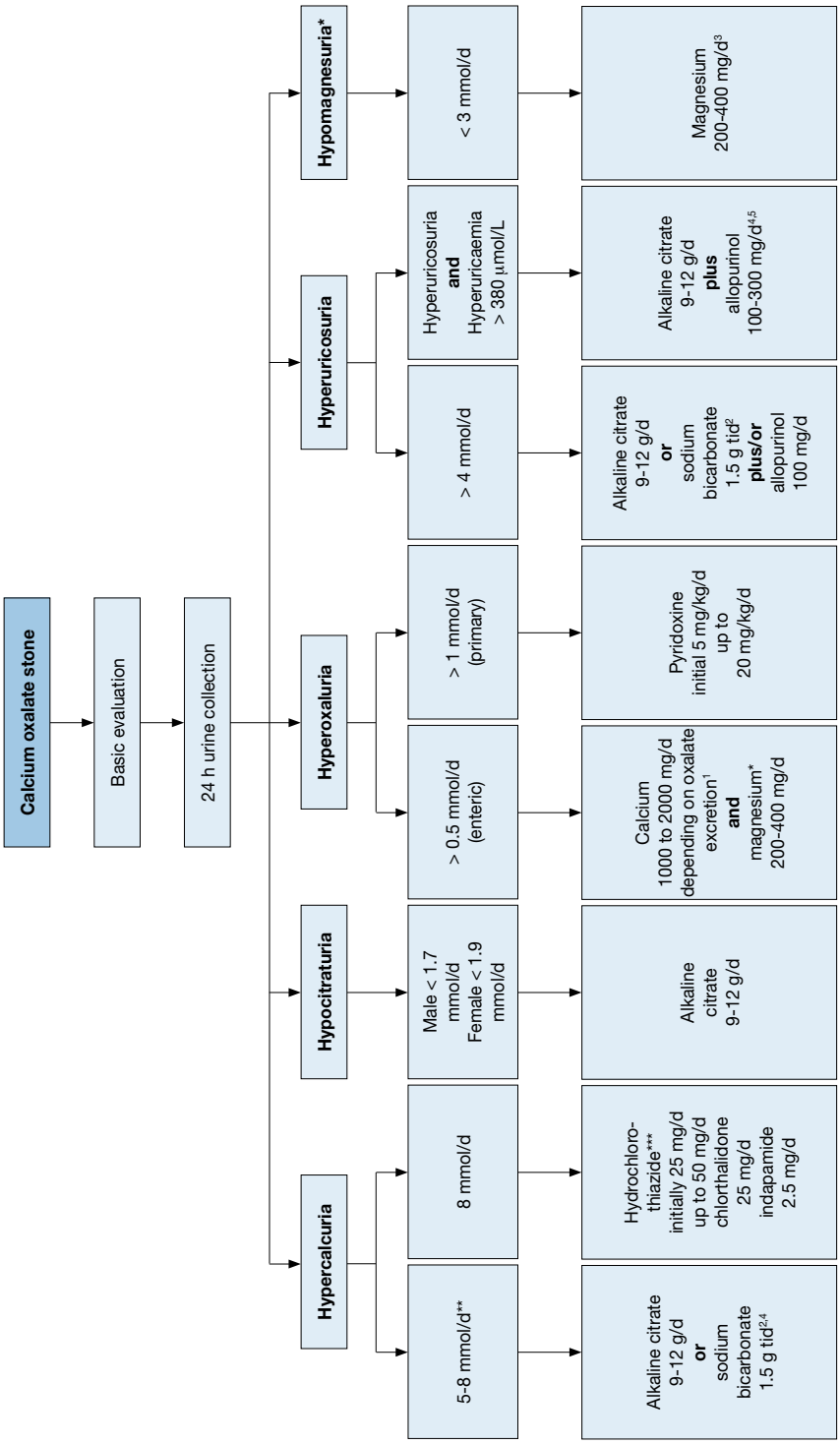


Figure 4.3: Therapeutic algorithm for calcium oxalate stones



[1] *Be aware of excess calcium excretion.*

[2] *tid = three times/day (24h).*

[3] *No magnesium therapy for patients with renal insufficiency.*

[4] *There is no evidence that combination therapy (thiazide + citrate) or (thiazide + allopurinol) is superior to thiazide therapy alone [584, 617].*

[5] *Febuxostat 80 mg/day.*

** low evidence (see text)*

***Calciuria is a continuous variable and treatment may be adjusted to clinical need even when below the threshold indicated.*

****Patients on hydrochlorothiazides should be advised to get their skin checked on a regular basis as they have a higher risk for developing non-melanoma skin cancer (NMSC). In patients with history of NMSC the indication for the intake of hydrochlorothiazides should be thoroughly reviewed [614, 615].*

4.4.3 Specific treatment

General preventive measures are recommended for fluid intake and diet. Hyperoxaluric stone formers should consume foods with low oxalate content, whereas hyperuricosuric stone formers benefit from daily dietary reduction of purine. Figure 4.3 summarises the pharmacological treatment of calcium oxalate stones [557, 562, 583-586, 589, 590, 592, 595, 598-600, 602-609, 616, 618-620]. There is only low-level evidence for the efficacy of preventing stone recurrence based on pre-treatment stone composition examination and biochemistry measures, or on-treatment biochemistry measures [557].

4.4.4 Summary of evidence and guidelines for pharmacological treatments for patients with specific abnormalities in urine composition (based on 24-hour urine samples)

Summary of evidence	LE
Thiazide or alkaline citrates or both can reduce stone formation.	1a
Oxalate restriction is beneficial if hyperoxaluria is present.	2b
Alkaline citrates can reduce stone formation in enteric hyperoxaluria.	4
Calcium supplement can reduce stone formation in enteric hyperoxaluria.	2
A diet low in fat and oxalate can be beneficial in reducing stone formation.	3
Alkaline citrates and sodium bicarbonate can be used if hypocitraturia is present.	1b
Allopurinol is first-line treatment of hyperuricosuria.	1a
Febuxostat is second-line treatment of hyperuricosuria.	1b
Avoid excessive intake of animal protein in hyperuricosuria.	1b
Restricted intake of salt is beneficial if there is high urinary sodium excretion.	1b

Recommendations	Strength rating
Prescribe thiazide or alkaline citrates or both in case of hypercalciuria*.	Strong
Advise oxalate restriction if hyperoxaluria is present.	Weak
Offer alkaline citrates in enteric hyperoxaluria.	Weak
Offer calcium supplement in enteric hyperoxaluria.	Weak
Advise reduced dietary fat and oxalate in enteric hyperoxaluria.	Weak
Prescribe alkaline citrates and sodium bicarbonate in case of hypocitraturia.	Strong
Prescribe allopurinol in case of hyperuricosuria.	Strong
Offer febuxostat as second-line treatment of hyperuricosuria.	Strong
Avoid excessive intake of animal protein in hyperuricosuria.	Strong
Advise restricted intake of salt if there is high urinary sodium excretion.	Strong

** Patients on hydrochlorothiazides should be advised to get their skin checked on a regular basis as they have a higher risk of developing a non-melanoma skin cancer (NMSC). In patients with history of NMSC the indication for the intake of hydrochlorothiazides should be thoroughly reviewed [614, 615].*

4.5 Calcium phosphate stones [557, 583, 592, 602, 603, 607, 621]

Some calcium phosphate stone formers are at high risk of recurrence. Further information on identifying high-risk patients is provided in section 3.1.3.

Calcium phosphate mainly appears in two completely different minerals: carbonate apatite and brushite. Carbonate apatite crystallisation occurs at a pH > 6.8 and may be associated with infection. Brushite crystallises at an optimum pH of 6.5-6.8 at high urinary concentrations of calcium (> 8 mmol/day) and phosphate (> 35 mmol/day). Its occurrence is not related to UTI. Possible causes of calcium phosphate stones include HPT, RTA and UTI; each of which requires different therapy.

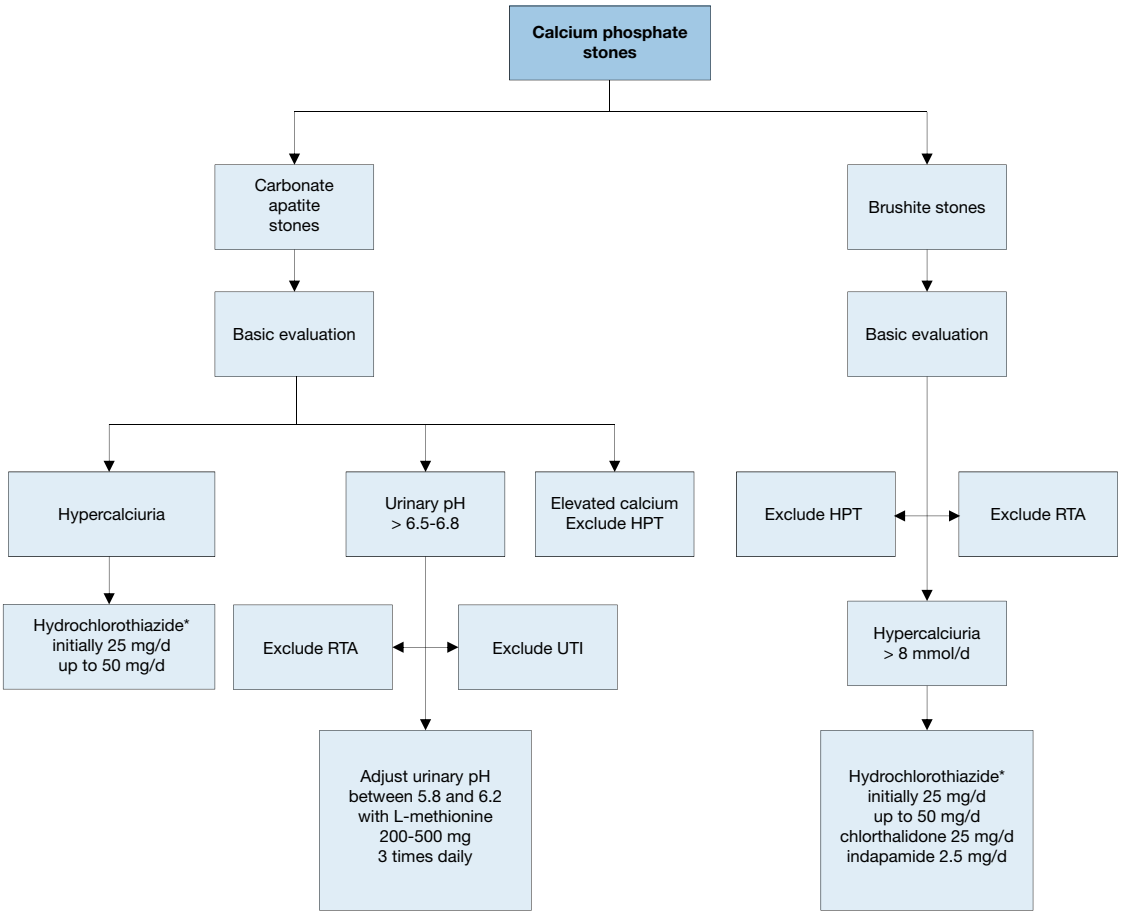
4.5.1 Diagnosis

Diagnosis requires blood analysis for: creatinine, sodium, potassium, chloride, ionised calcium (or total calcium + albumin), phosphate, and PTH (in the case of increased calcium levels). Urinalysis includes measurement of: volume, urine pH profile, specific weight, calcium, phosphate and citrate.

4.5.2 Interpretation of results and aetiology

General preventative measures are recommended for fluid intake and diet. The diagnostic and therapeutic algorithm for calcium phosphate stones is shown in Figure 4.4.

Figure 4.4: Diagnostic and therapeutic algorithm for calcium phosphate stones



HPT = hyperparathyroidism; RTA = renal tubular acidosis; UTI = urinary tract infection.

** Patients on hydrochlorothiazides should be advised to get their skin checked on a regular basis as they have a higher risk for developing non-melanoma skin cancer (NMSC). In patients with history of NMSC the indication for the intake of hydrochlorothiazides should be thoroughly reviewed [614, 615].*

*4.5.3 **Pharmacological therapy** [557, 583, 592, 602, 603, 607, 621]*

Hyperparathyroidism and RTA are common causes of calcium phosphate stone formation. Most patients with primary HPT require surgery. Renal tubular acidosis can be corrected pharmacologically including with bicarbonate or alkaline citrate therapy. If primary HPT and RTA have been excluded, pharmacotherapy for calcium phosphate calculi depends on effective reduction of urinary calcium levels using thiazides. For infection-associated calcium phosphate stones, it is important to consider the guidance given for infection stones.

*4.5.4 **Summary of evidence and guidelines for the management of calcium phosphate stones***

Summary of evidence	LE
Thiazide is beneficial in case of hypercalciuria.	1a

Recommendation	Strength rating
Prescribe thiazide in case of hypercalciuria.	Strong

4.6 Disorders and diseases related to calcium stones

*4.6.1 **Hyperparathyroidism** [622-624]*

Primary HPT is responsible for an estimated 5% of all calcium stone formation. Renal stones occur in approximately 20% of patients with primary HPT. Elevated levels of PTH significantly increase calcium turnover, leading to hypercalcaemia and hypercalciuria and bone disease. Serum calcium may be mildly elevated and serum PTH may be within the upper normal limits and, therefore, repeated measurements may be needed;

preferably with the patient fasting. Stones of HPT patients may contain both calcium oxalate and calcium phosphate. Nephrocalcinosis and CKD may also occur.

If HPT is suspected, neck exploration should be performed to confirm the diagnosis. Primary HPT can only be cured by surgery.

*4.6.2 **Granulomatous diseases** [625]*

Granulomatous diseases, such as sarcoidosis, may be complicated by hypercalcaemia and hypercalciuria secondary to increased calcitriol production. The latter is independent of PTH control, leading to increased calcium absorption in the gastrointestinal tract and suppression of PTH. Treatment focuses on the activity of the granulomatous diseases and may require steroids, hydroxychloroquine or ketoconazole. Treatment should be reserved for a specialist.

*4.6.3 **Primary hyperoxaluria** [601]*

Patients with primary hyperoxaluria (PH) should be referred to specialised centres, as successful management requires an experienced interdisciplinary team. The main therapeutic aim is to reduce endogenous oxalate production, which is increased in patients with PH. In approximately one-third of patients with PH type I, pyridoxine therapy normalises or significantly reduces urinary oxalate excretion. The goal of adequate urine dilution is achieved by adjusting fluid intake to 3.5-4.0 L/day in adults (children 1.5 L/m^2 body surface area) and following a circadian drinking regimen.

Therapeutic options for preventing calcium oxalate crystallisation include hyperdiuresis, alkaline citrates, magnesium and Lumasiran, an RNAi agent, a new treatment for reducing the synthesis of oxalate of PH type 1 [626]. However, in end-stage renal failure, PH requires simultaneous liver-kidney transplantation.

Treatment regimens are:

- pyridoxine in PH type I: 5-20 mg/kg/day according to urinary oxalate excretion and patient tolerance;
- alkaline citrate: 9-12 g/day in adults, 0.1-0.15 mq/kg/day in children;
- magnesium: 200-400 mg/day (no magnesium in the case of renal insufficiency);
- Lumasiran: Subcutaneous injection with dose and timing adjusted according to body weight and duration of treatment.

4.6.3.1 Summary of evidence and guideline for the management of primary hyperoxaluria

Summary of evidence	**LE**
Pyridoxine can reduce the urinary oxalate excretion in primary hyperoxaluria.	3

Recommendation	**Strength rating**
Prescribe pyridoxine for primary hyperoxaluria.	Strong

*4.6.4 **Enteric hyperoxaluria** [571, 576, 627-629]*

Enteric hyperoxaluria is a particularly problematic condition in patients with intestinal malabsorption of fat. This abnormality is associated with a high risk of stone formation and is seen after intestinal resection and malabsorptive bariatric surgery, as well as in Crohn's disease and pancreas insufficiency. In addition to hyperoxaluria, these patients usually present with hypocitraturia due to loss of alkali. Urine pH is usually low, as are urinary calcium and urine volume. All these abnormalities contribute to high levels of supersaturation with calcium oxalate, crystalluria, stone formation, and less frequently to nephrocalcinosis and CKD. Specific preventive measures are:

- restricted intake of oxalate-rich foods [571];
- restricted fat intake [571];
- calcium supplementation at meal times to enable calcium oxalate complex formation in the intestine [576, 627-629];
- sufficient fluid intake to balance intestinal loss of water caused by diarrhoea;
- alkaline citrates to raise urinary pH and citrate.

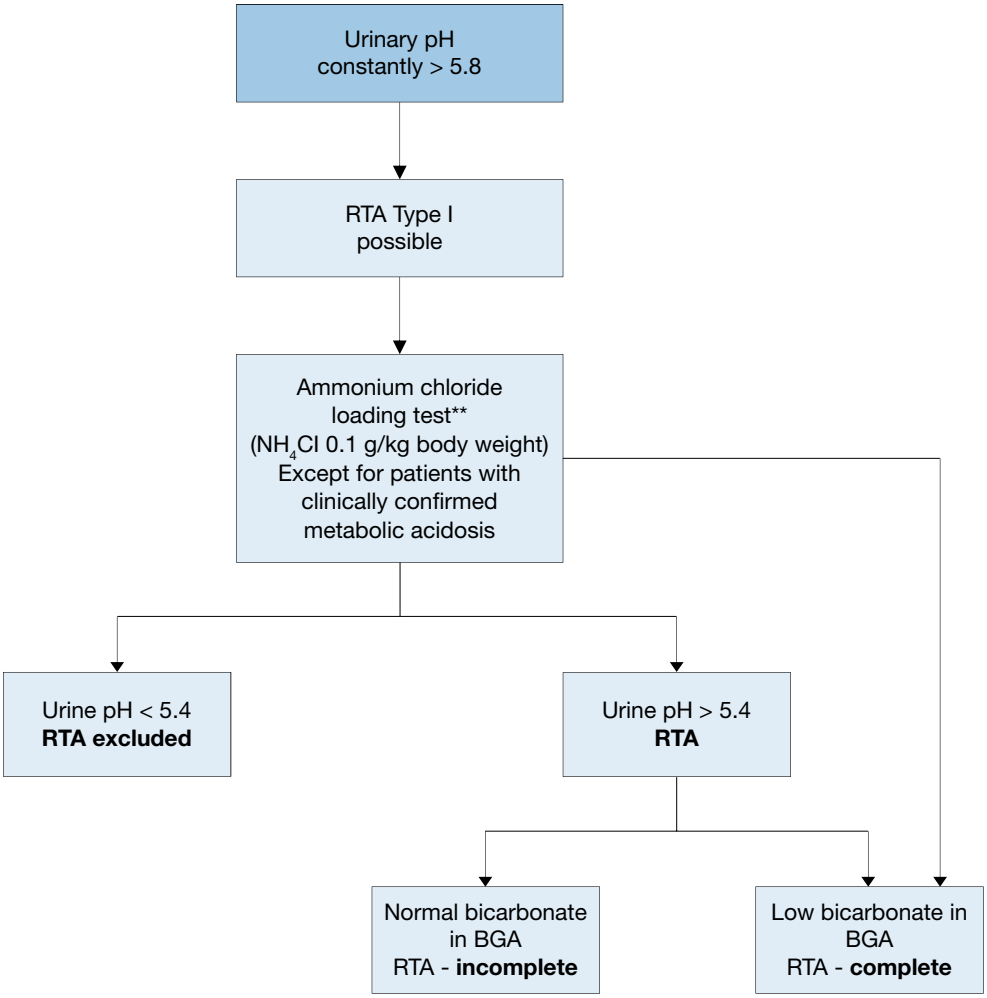
Summary of evidence	**LE**
Alkaline citrates can be beneficial to replace citrate loss and raise urine pH.	3
Calcium supplements with meals enable calcium oxalate complex formation in the intestine.	2
Reduction in dietary fat and oxalate can be beneficial in intestinal malabsorption.	3

Recommendations	Strength rating
Prescribe alkaline citrates for enteric hyperoxaluria.	Weak
Advise patients to take calcium supplements with meals.	Weak
Advise patients to follow a diet with a low fat and oxalate content.	Weak

4.6.5 ***Renal tubular acidosis*** *[557, 592, 630, 631]*

Renal tubular acidosis is caused by severe impairment of proton or bicarbonate handling along the nephron. Kidney stone formation most probably occurs in patients with distal RTA type I. Figure 4.5 outlines the diagnosis of RTA. Table 4.7 shows acquired and inherited causes of RTA.

Figure 4.5: Diagnosis of renal tubular acidosis



BGA = blood gas analysis; RTA = renal tubular acidosis.

*** An alternative ammonium chloride loading test using NH4Cl load with 0.05 g/kg body weight over three days might provide similar results and may be better tolerated by the patient. A second alternative in these cases could be the furosemide/fludrocortisone acidification test [632].*

Renal tubular acidosis can be acquired or inherited. Reasons for acquired RTA can be chronic obstructive uropathy, recurrent pyelonephritis, acute tubular necrosis, renal transplantation, analgesic nephropathy, sarcoidosis, Sjögren syndrome and other autoimmune diseases, medullary sponge kidney, liver cirrhosis, sickle cell anaemia, idiopathic hypercalciuria, and primary parathyroidism; it may also be drug-induced (e.g., amphotericin B, foscarnet, lithium, zonisamide).

Table 4.7: Inherited causes of renal tubular acidosis

Type - inheritance	Gene/gene product/function	Phenotype
Autosomal dominant	SLC4A1/AE1/Cl-bicarbonate exchanger	Hypercalciuria, hypokalaemia, rickets/osteomalacia
Autosomal recessive with hearing loss	ATP6V1B1/B1 sub-unit of vacuolar H-ATPase/proton secretion	Hypercalciuria, hypokalaemia, rickets/osteomalacia
Autosomal recessive	ATP6V0A4/A4 sub-unit of vacuolar H-ATPase/proton secretion	Hypercalciuria, hypokalaemia, rickets/osteomalacia

More rarely biallelic causative variants in FOXI1 and WDR72 genes have also been identified. The main therapeutic aim of RTA treatment is restoring a normal acid-base equilibrium. Despite the alkaline pH of urine in RTA, alkalinisation using alkaline citrates or sodium bicarbonate is important for normalising the metabolic changes (intracellular acidosis) responsible for stone formation (Table 4.8) and bone demineralisation. The alkali load reduces tubular re-absorption of citrate, which in turn normalises citrate excretion. Therapeutic success can be monitored by venous blood gas analysis (base excess: ± 2.0 mmol/L) in complete RTA. If excessive calcium excretion (> 8 mmol/day) persists after re-establishing acid-base equilibrium, thiazides may lower urinary calcium excretion.

Table 4.8: Pharmacological treatment of renal tubular acidosis

Biochemical risk factor	Indication for pharmacological therapy	Medication
Hypercalciuria	Calcium excretion > 8 mmol/day	Hydrochlorothiazide*, - in adults: 25 mg/day initially, up to 50 mg/day - in children: 0.5-1 mg/kg/day Alternatives in adults: Chlorthalidone 25 mg/day Indapamide 2.5 mg/day
Inadequate urine pH	Citrate excretion < 320 mg/day	Alkaline citrate, 9-12 g/day divided in three doses ***OR*** Sodium bicarbonate, 1.5 g, three times daily

** Patients on hydrochlorothiazides should be advised to get their skin checked on a regular basis as they have a higher risk of developing non-melanoma skin cancer (NMSC). In patients with history of NMSC the indication for the intake of hydrochlorothiazides should be thoroughly reviewed [614, 615].*

4.6.5.1 Summary of evidence and guidelines for the management of tubular acidosis

Summary of evidence	LE
Alkaline citrates can be beneficial in distal renal tubular acidosis to correct the intracellular acidosis.	2b
Thiazide and alkaline citrates are beneficial for hypercalciuria.	1a

Recommendations	Strength rating
Prescribe alkaline citrates for distal renal tubular acidosis.	Strong
Prescribe thiazide and alkaline citrates for hypercalciuria.	Strong

*4.6.6 **Nephrocalcinosis** [633]*

Nephrocalcinosis (NC) refers to increased calcium crystal deposition within the renal cortex or medulla and occurs alone or in combination with renal stones. There are various metabolic causes. The main causes are: HPT, primary and enteric hyperoxalurias, genetic and acquired RTA, medullary sponge kidney, vitamin D metabolic disorders, sarcoidosis, idiopathic hypercalciuria and hypocitraturia, and genetic disorders, including Dent's disease, Bartter's syndrome. The many causes of NC mean there is no single standard therapy. Therapeutic attention must focus on the underlying metabolic or genetic disease, on the frequent association with CKD while minimising the biochemical risk factors.

4.6.6.1 Diagnosis

Diagnosis requires the following blood analysis: PTH (in the case of increased calcium levels), vitamin D and metabolites, vitamin A, sodium, potassium, magnesium, chloride, and bicarbonate. Urinalysis should investigate urine pH profile at different times of the day [634], daily urine volume, specific weight of urine, and levels of calcium, oxalate, phosphate, uric acid, magnesium, and citrate.

4.7 Uric acid and ammonium urate stones

All uric acid and ammonium urate stone formers are considered to be at high risk of recurrence [25]. Uric acid nephrolithiasis is responsible for approximately 10% of renal stones [635] and associated with hyperuricosuria or low urinary pH. Hyperuricosuria may be a result of dietary excess, endogenous overproduction (enzyme defects), myeloproliferative disorders, chemotherapy drugs, gout or catabolism [636]. Low urinary pH may be caused by decreased urinary ammonium excretion (insulin resistance or gout), increased endogenous acid production (insulin resistance, metabolic syndrome, or exercise-induced lactic acidosis), increased acid intake (high animal protein intake), or increased base loss (diarrhoea) [636].

Ammonium urate stones are extremely rare, comprising < 1% of all types of urinary stones. They are associated with UTI, malabsorption (inflammatory bowel disease and ileostomy diversion or laxative abuse), phosphate deficiency, hypokalemia and malnutrition. Suggestions on uric acid and ammonium urate nephrolithiasis are based on level 3 and 4 evidence. Chronic kidney disease is frequently observed.

*4.7.1 **Diagnosis***

Figure 4.6 shows the diagnostic algorithm for uric acid stones and figure 4.7 shows the therapeutic algorithm for uric acid and ammonium urate stones. Blood analysis requires measurement of creatinine, potassium, and uric acid levels. Urinalysis requires measurement of urine volume, urine pH profile, specific weight of urine, and uric acid level. Urine culture is needed in the case of ammonium urate stones.

*4.7.2 **Interpretation of results***

Uric acid and ammonium urate stones form under completely different biochemical conditions. Acidic arrest (circadian urine pH constantly < 5.8) promotes uric acid crystallisation.

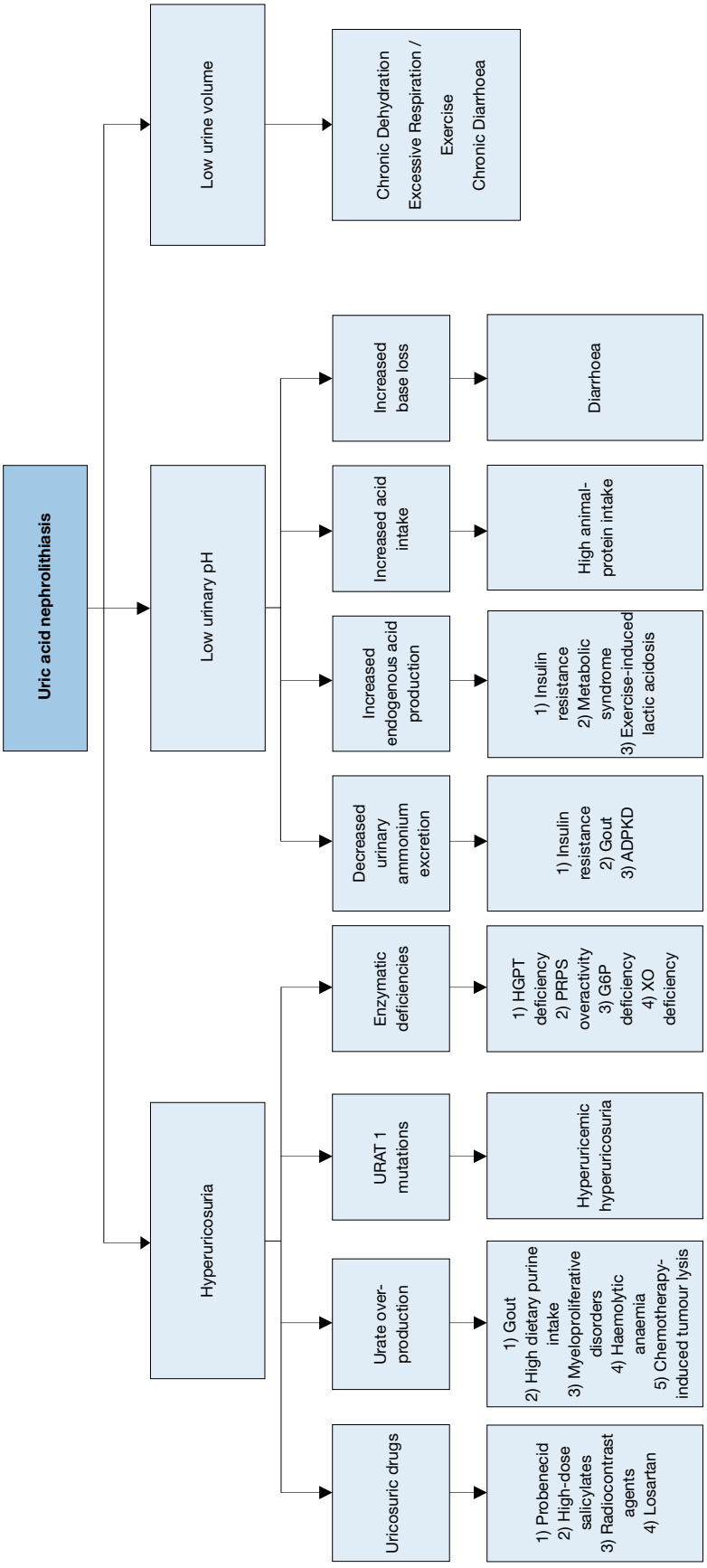
Hyperuricosuria is defined as uric acid excretion > 4 mmol/day in adults or > 0.12 mmol/kg/day in children. Hyperuricaemia may be present, but there is only weak evidence for its association with stone formation [637].

Hyperuricosuric calcium oxalate stone formation can be distinguished from uric acid stone formation by urinary pH, which is usually > 5.5 in calcium oxalate stone formation and < 5.5 in uric acid stone formation and occasional absence of hyperuricosuria in patients with pure uric acid stones [638, 639]. Ammonium urate crystals form in urine at pH > 6.5, high uric acid concentration when ammonium is present [640, 641].

*4.7.3 **Specific treatment***

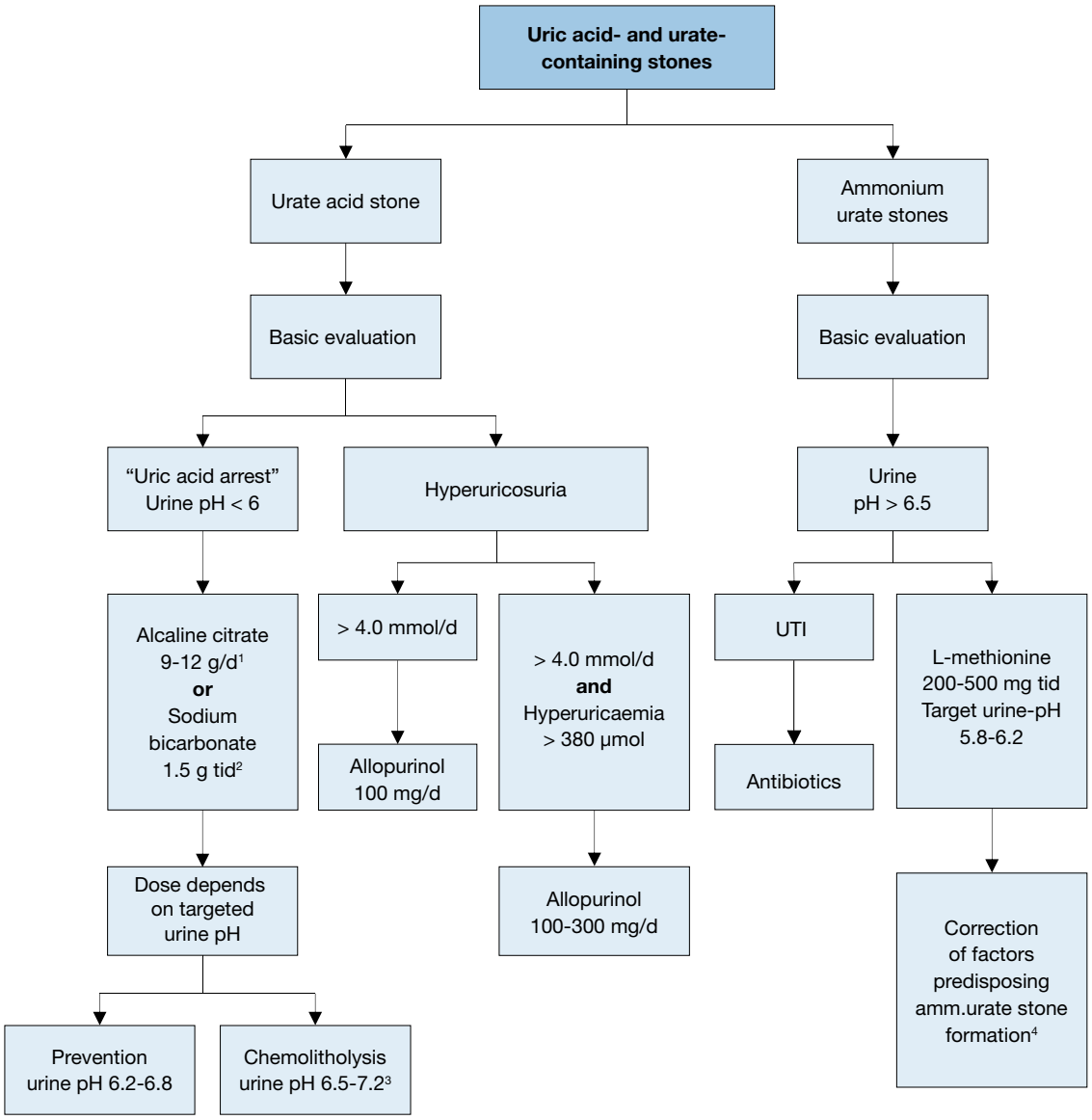
General preventive measures are recommended for fluid intake and diet. Hyperuricosuric stone formers benefit from purine reduction in their daily diet. Figure 4.6 describes pharmacological treatment [25, 547, 635, 638-647]. For uric acid stones, allopurinol may change the stone composition distribution in patients with gout to a pattern similar to that in stone formers without gout [648].

Figure 4.6: Diagnostic algorithm for uric acid stones



ADPKD = autosomal dominant polycystic kidney disease; G6P = glucose-6 phosphate dehydrogenase; HGPT = hypoxanthine guanine phosphorybosyl transferase; PRPS = phosphoribosyl-pyrophosphate synthetase superactivity; XO = xanthine oxidase.

Figure 4.7: Therapeutic algorithm for uric acid- and ammonium-urate stones



[1] d: day.
[2] tid: three times a day.
[3] A higher pH may lead to calcium phosphate stone formation.
[4] In patients with high uric acid excretion, allopurinol may be helpful.

4.7.4 Summary of evidence and guidelines for the management of uric acid- and ammonium urate stones

Summary of evidence	LE
Alkaline citrates can be beneficial to alkalinise the urine in uric acid stone formers.	3
Allopurinol can be beneficial in hyperuricosuric urate stone formers.	1b

Recommendations	Strength rating
Prescribe alkaline citrates to alkalinise the urine in uric acid stone formers.	Strong
Prescribe allopurinol in hyperuricosuric urate stone formers.	Strong

4.8 Struvite and infection stones

All infection-stone formers are deemed at high risk of recurrence. Struvite stones represent 2-15% of the stones sent for analysis. Stones that contain struvite may originate *de novo* or grow on pre-existing stones, which are infected with urea-splitting bacteria [649]. There are several factors predisposing patients to struvite stone formation (Table 4.9) [650].

*4.8.1 **Diagnosis***

Blood analysis requires measurement of creatinine, and urinalysis requires repeat urine pH measurements and urine culture.

*4.8.2 **Interpretation***

Infection stones contain the following minerals: struvite and/or carbonate apatite and/or ammonium urate. Urine culture typically provides evidence for urease-producing bacteria, which increase ammonia ions and develop alkaline urine (Table 4.10). Carbonate apatite starts to crystallise at a urine pH level of 6.8. Struvite only precipitates at pH > 7.2 [651, 652]. *Proteus mirabilis* accounts for more than half of all urease-positive UTIs [653, 654].

*4.8.3 **Specific treatment***

General preventive measures are recommended for fluid intake and diet. Specific measures include complete surgical stone removal [650], short- or long-term antibiotic treatment [655], urinary acidification using methionine [597] or ammonium chloride [656], and advice to restrict intake of urease [657, 658]. For severe infections, acetohydroxamic acid may be an option [657, 658] (Figure 4.8); however, it is not licensed/available in all European countries.

Eradication of infection after complete stone removal is desirable. The evidence regarding the duration of post-operative antibiotic administration is inconclusive.

Summary of evidence	LE
Removing the stone material as completely as possible with surgery can reduce ongoing infection.	3
Antibiotics are beneficial after complete stone removal.	3
Ammonium chloride, 1 g, two or three times daily, can ensure urinary acidification to prevent recurrent infection.	3
Methionine, 200-500 mg, one to three times daily, can be used as an alternative to ammonium chloride, to ensure urinary acidification.	3
Urease inhibitors in case of severe infection are occasionally used (if licensed).	1b

Recommendations	Strength rating
Surgically remove the stone material as completely as possible.	Strong
Prescribe antibiotics in case of persistent bacteriuria.	Strong
Prescribe ammonium chloride, 1 g, two or three times daily to ensure urinary acidification.	Weak
Prescribe methionine, 200-500 mg, one to three times daily, as an alternative, to ensure urinary acidification.	Weak

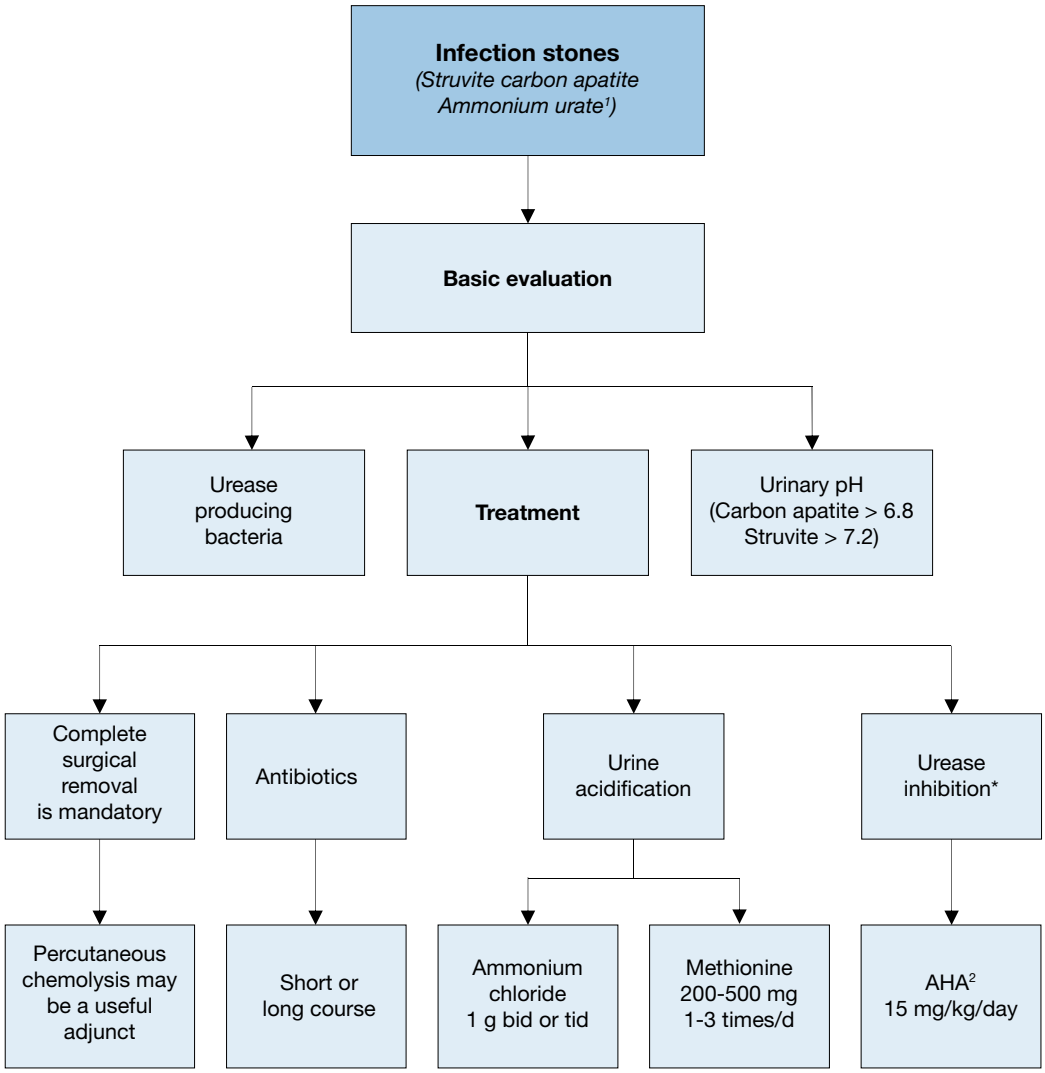
Table 4.9: Factors predisposing to struvite stone formation

• Neurogenic bladder • Spinal cord injury/paralysis • Continent urinary diversion • Ileal conduit • Foreign body • Stone disease • Indwelling urinary catheter	• Urethral stricture • Benign prostatic hyperplasia • Bladder diverticulum • Cystocele • Calyceal diverticulum • UPJ obstruction

Table 4.10: Most important species of urease-producing bacteria

Obligate urease-producing bacteria (> 98%)
• *Proteus spp.* • *Providencia rettgeri* • *Morganella morganii* • *Corynebacterium urealyticum* • *Ureaplasma urealyticum*
Facultative urease-producing bacteria
• *Enterobacter gergoviae* • *Klebsiella spp.* • *Providencia stuartii* • *Serratia marcescens* • *Staphylococcus spp.*
CAUTION: *0-5% of Escherichia coli, Enterococcus spp. and Pseudomonas aeruginosa strains may produce urease.*

Figure 4.8: Diagnostic and therapeutic algorithm for infection stones



[1] *Discussed with uric acid stones.*
[2] *Acetohydroxamic acid*
** When nationally available.*
bid = twice a day; tid = three times a day; AHA = acetohydroxamic acid.

4.9 Cystine stones

Cystine stones account for 1-2% of all urinary stones in adults and 6-8% of the stones reported in paediatric studies [36, 659]. All cystine stone formers are deemed at high risk of recurrence and CKD [660, 661].

4.9.1 ***Diagnosis***

Blood analysis includes measurement of creatinine, and urinalysis includes measurement of urine volume, pH profile, specific weight, and cystine.

Interpretation

- Cystine is poorly soluble in urine and crystallises spontaneously within the physiological urinary pH range.
- Cystine solubility depends strongly on urine pH: at pH 6.0, the limit of solubility is 1.33 mmol/L.
- Routine analysis of cystine is not suitable for therapeutic monitoring.
- Regardless of phenotype or genotype of the cystinuric patient, the clinical manifestations are the same [662].
- There is no role for genotyping patients in the routine management of cystinuria [663, 664].
- Reductive therapy targets the disulphide binding in the cystine molecule. For therapy monitoring, it is essential to differentiate between cystine, cysteine and drug-cysteine complexes. Only high-performance liquid chromatography (HPLC)-based analysis differentiates between the different complexes formed by therapy.
- Diagnosis is established by stone analysis. The typical hexagonal crystals are detectable in only 20-25% of urine specimens from patients with cystinuria [665].
- The cyanide nitroprusside colorimetric qualitative test detects the presence of cystine at a threshold concentration of 75 mg/L, with a sensitivity of 72% and specificity of 95%. False-positive results in patients with Fanconi's syndrome, homocystinuria, or those taking various drugs, including infection stones [666].
- Quantitative 24-hour urinary cystine excretion confirms the diagnosis in the absence of stone analysis.
- Levels above 0.125 mmol/day (30 mg/day) are considered abnormal [667, 668].

4.9.2 ***Specific treatment***

General preventative measures for fluid intake and diet are recommended. A diet low in methionine may theoretically reduce urinary excretion of cystine; however, patients are unlikely to comply sufficiently with such a diet. A restricted intake of sodium is more easily achieved and is more effective in reducing urinary cystine. Patients are usually advised to avoid sodium consumption > 2 g/day (5 g NaCl) [669]. A high level of diuresis is of fundamental importance, aiming for a 24-hour urine volume of > 3 L [662, 665, 669, 670]. A considerable fluid intake evenly distributed throughout the day is necessary.

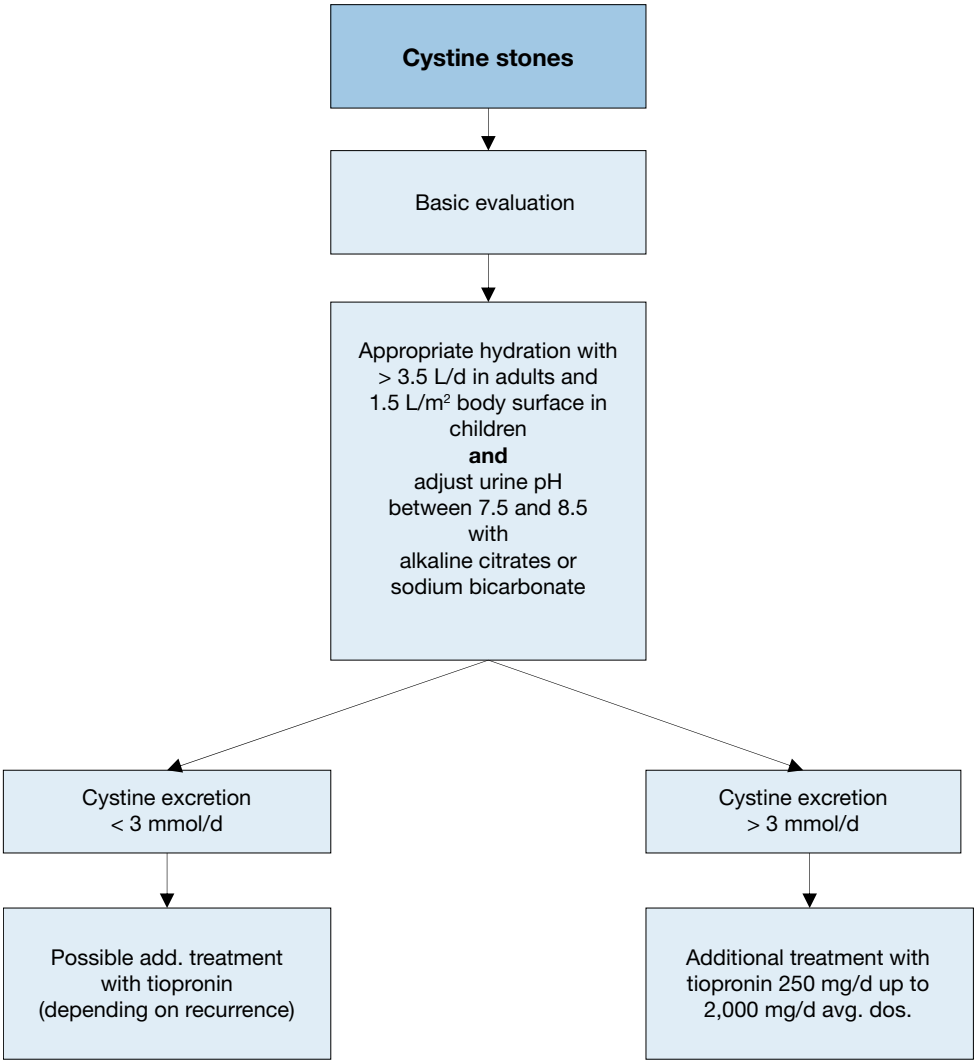
4.9.2.1 Pharmacological treatment of cystine stones

The main therapeutic option for avoiding cystine crystallisation is to maintain urine pH > 7.5, to improve cysteine solubility and ensure appropriate hydration with a minimum of 3.5 L/day in adults, or 1.5 L/m^2 body surface area in children [662, 665, 669, 670].

Free cystine concentration can be decreased by reductive substances, which act by splitting the disulphide binding of cystine.

Tiopronin is currently the best choice for cystine reduction. However, side effects often lead to treatment termination, for example when nephrotic syndrome develops or when there is poor compliance, especially with long-term use. After carefully considering the risk of early tachyphylaxis, put into place a dose-escape phenomenon for long-term use, and recurrence risk, tiopronin is recommended at cystine levels > 3.0 mmol/day (720 mg/day) or in the case of recurring stone formation, notwithstanding other preventive measures [662, 665, 669, 670].

Figure 4.9: Metabolic management of cystine stones



4.9.3 Summary of evidence and guidelines for the management of cystine stones

Summary of evidence	**LE**
Increasing fluid intake so that 24-hour urine volume exceeds 3 L is used to dilute the cystine.	3
Alkaline citrates 3-10 mmol two or three times daily can be used to achieve pH > 7.5.	3
Tiopronin, 250-2,000 mg/day can be used to reduce stone formation in patients with cysteine excretion, > 3 mmol/day, or when other measures are insufficient.	3

Recommendations	**Strength rating**
Therapeutic measures	
Urine dilution Advise patients to increase their fluid intake so that 24-hour urine volume exceeds 3 L.	Strong
Alkalinisation Prescribe potassium citrate 3-10 mmol two or three times daily, to achieve pH > 7.5 for patients with cystine excretion < 3 mmol/day.	Strong
Complex formation with cystine For patients with cystine excretion, > 3 mmol/day, or when other measures are insufficient: prescribe in addition to other measures tiopronin, 250-2,000 mg/day.	Strong

4.10 2,8-Dihydroxyandenine stones and xanthine stones

All 2,8-Dihydroxyadenine and xanthine stone formers are considered to be at high risk of recurrence. Both stone types are rare. Diagnosis and specific prevention are similar to those for uric acid stones [25].

*4.10.1 **2,8-Dihydroxyadenine stones***

A genetically determined defect of adenine phosphoribosyl transferase causes high urinary excretion of poorly soluble 2,8-Dihydroxyadenine [671]. High-dose allopurinol or febuxostat are important options but should be given with regular monitoring [672].

*4.10.2 **Xanthine stones***

Patients who form xanthine stones usually show decreased levels of serum uric acid. There is no available pharmacological intervention.

*4.10.3 **Fluid intake and diet***

Recommendations for general preventive measures apply. Pharmacological intervention is difficult; therefore, high fluid intake ensures optimal specific weight levels of urine < 1.010 (urine specific gravity). A purine-reduced diet decreases the risk of spontaneous crystallisation in urine.

4.11 Drug-induced stones

Drug stones are induced by pharmacological treatment [583, 673] (Table 4.10). Two types exist:

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

Table 4.11: Compounds that cause drug stones

Active compounds crystallising in urine	Substances impairing urine composition
• Allopurinol/oxypurinol • Amoxicillin/ampicillin • Ceftriaxone • Quinolones • Ephedrine • Indinavir and other HIV-protease inhibitors • Magnesium trisilicate • Sulphonamides • Triamterene	• Acetazolamide • Allopurinol • Aluminium magnesium hydroxide • Ascorbic acid • Calcium • Furosemide • Laxatives • Losartan • Methoxyflurane • Orlistat • Vitamin D • Topiramate • Zonisamide

4.12 Matrix Stones

Pure matrix stones are extremely rare with less than 70 cases described in the literature. They are more prevalent in females. The main risk factors are recurrent UTIs, especially due to *P. mirabilis* or *E. coli*, previous surgery for stone disease, chronic renal failure, and haemodialysis. Complete endourological removal, frequently via the percutaneous approach, is critical. Given the rarity of matrix calculi a specific prophylactic regimen to minimise recurrence cannot be recommended. Eliminating infections and prophylactic use of antibiotics are most commonly proposed [674].

4.13 Unknown stone composition [18]

An accurate medical history is the first step towards identifying risk factors as summarised below (see section 4.13.1).

Diagnostic imaging begins with US examination of both kidneys to establish whether the patient is stone free. Stone detection by US should be followed by KUB and unenhanced multislice CT in adults to differentiate between calcium-containing and non-calcium stones.

Blood analysis demonstrates severe metabolic and organic disorders, such as renal insufficiency, HPT or other hypercalcaemic states and hyperuricaemia. In children, hyperoxalaemia should additionally be screened for.

Urinalysis is performed routinely with a dipstick test as described above. Urine culture is required if there are signs of infection. Constant urine pH < 5.8 in the daily profile may indicate acidic arrest, which

could promote uric acid crystallisation. Persistent urine pH > 5.8 in the daily profile may indicate RTA, if UTI is excluded [629, 631].

Microscopy of urinary sediment can help to discover rare stone types because crystals of 2,8-Dihydroxyadenine, cystine and xanthine are pathognomonic for the corresponding disease. In cases in which the presence of cystine is doubtful, a cyanide nitroprusside colorimetric qualitative test can be used to detect the presence of cystine in urine, with a sensitivity of 72% and specificity of 95%. False-positive results are possible in patients with Fanconi's syndrome or homocystinuria, or in those taking various drugs, including ampicillin or sulfa-containing medication [666, 675].

Following this programme, the most probable stone type can be assumed, and specific patient evaluation can follow. However, if any expulsed stone material is available, it should be analysed by diagnostic confirmation or correction.

*4.13.1 **Recommendations for investigations for the assessment of patients with stones of unknown composition*** [19, 25, 67, 583]

Recommendations		**Strength rating**
Investigation	**Rationale for investigation**	
Take a medical history	• Stone history (former stone events, family history) • Dietary habits • Medication chart	Strong
Perform diagnostic imaging	• Ultrasound in the case of a suspected stone • Un-enhanced helical computed tomography • Determination of Hounsfield units provides information about the possible stone composition	Strong
Perform a blood analysis	• Creatinine • Calcium (ionised calcium or total calcium + albumin) • Uric acid	Strong
Perform a urinalysis	• Urine pH profile (measurement after each voiding, minimum four times daily) • Dipstick test: leukocytes, erythrocytes, nitrites, protein, urine pH, specific weight • Urine cultures • Microscopy of urinary sediment (morning urine) • Cyanide nitroprusside test (cystine exclusion) Further examinations depend on the results of the investigations listed above.	Strong

5. FOLLOW-UP OF URINARY STONES

Patients suffering from urolithiasis have a predisposition to develop symptoms, complications, and recurrence of stones. Despite the rich literature published on urolithiasis very little has been written about how urolithiasis patients should be monitored after their treatment.

There is no general agreement on whether and when stone patients should be released from follow-up, nor when and how follow-up should occur for patients who need it. The main reason for this lack of agreement is the great clinical heterogeneity of stone disease among patients.

The Panel performed a systematic review questioning the benefits and harms of scheduled follow-up for patients who underwent definitive treatment (ESWL, URS, PNL, medical chemoprophylaxis) for upper urinary tract stone disease [676] .

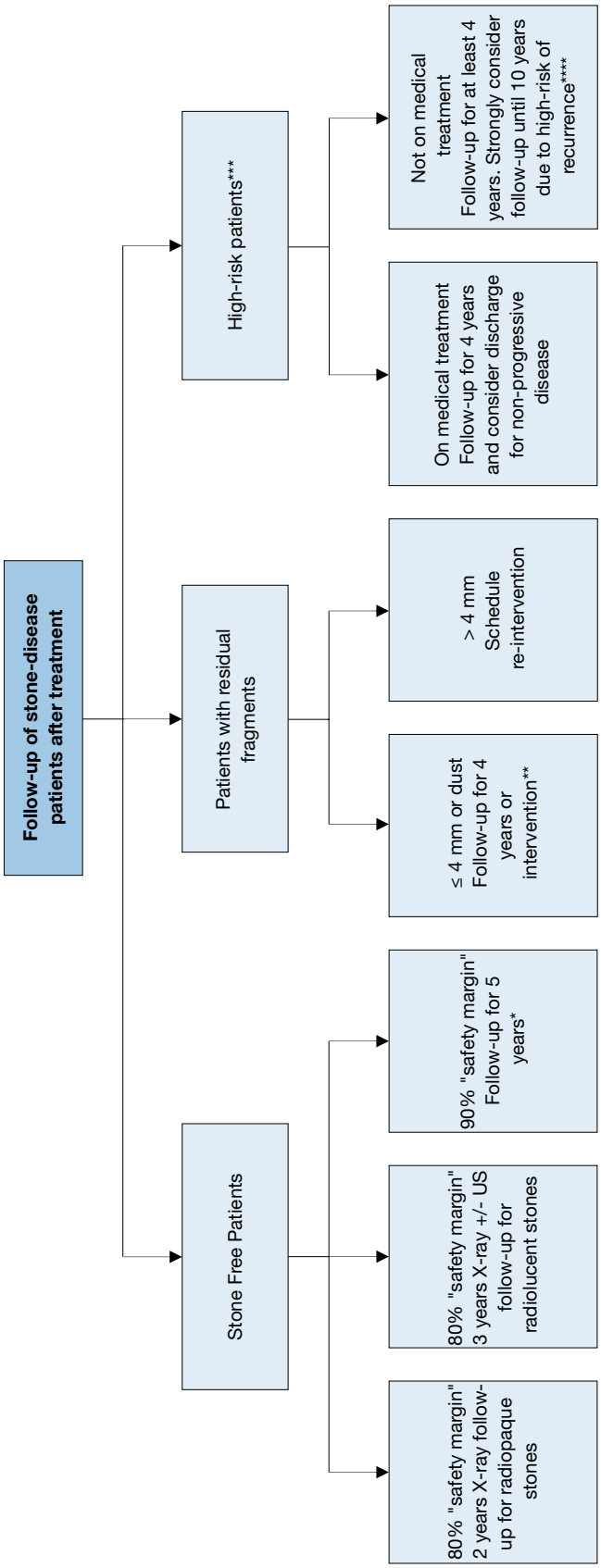
The Panel aimed to answer three main questions regarding urolithiasis follow-up: a) In patients with no residual fragments, does imaging follow-up after treatment for upper urinary tract stones offer more clinical benefits than harms compared with no scheduled follow-up?; b) In patients with residual fragments, does imaging follow-up after treatment for upper urinary tract stones offer more clinical benefits than harms compared with

no scheduled follow-up?; and c) Does biochemical urine analysis follow-up after treatment for upper urinary tract stones offer more clinical benefits than harms compared with no scheduled follow-up? There was a lack of comparative studies regarding follow-up vs. no follow-up, so the primary endpoints were not reached. The Panel used the data from the eligible observational and randomised studies included in the systematic review to identify the time of patient discharge after follow-up according to stone disease status (stone-free patients, patients with residual stones, patients with metabolic abnormalities), and to come to a consensus on frequency of follow-up and use of investigations.

From a pooled analysis of 5,467 stone-free patients, the Panel estimated that for a safety margin of 80%, patients should be followed-up using imaging, for at least two years (radiopaque stones), or at least three years (radiolucent stones) before discharge, while for a safety margin of 90% patients should be discharged after five years of no recurrence. Regarding residual disease, patients with fragments ≤ 4 mm could be offered surveillance for up to four years, since intervention rates range between 17-29%, disease progression between 9-34%, and spontaneous passage between 21-34% at 49 months. Patients with larger residual fragments should be offered further definitive intervention, since intervention rates are high (24-100%). Insufficient data exist for high-risk patients, but current literature dictates that patients who are adherent to targeted medical treatment seem to experience less stone growth or re-growth of residual fragments and may be discharged after 36-48 months of non-progressive disease on imaging (Figure 5.1).

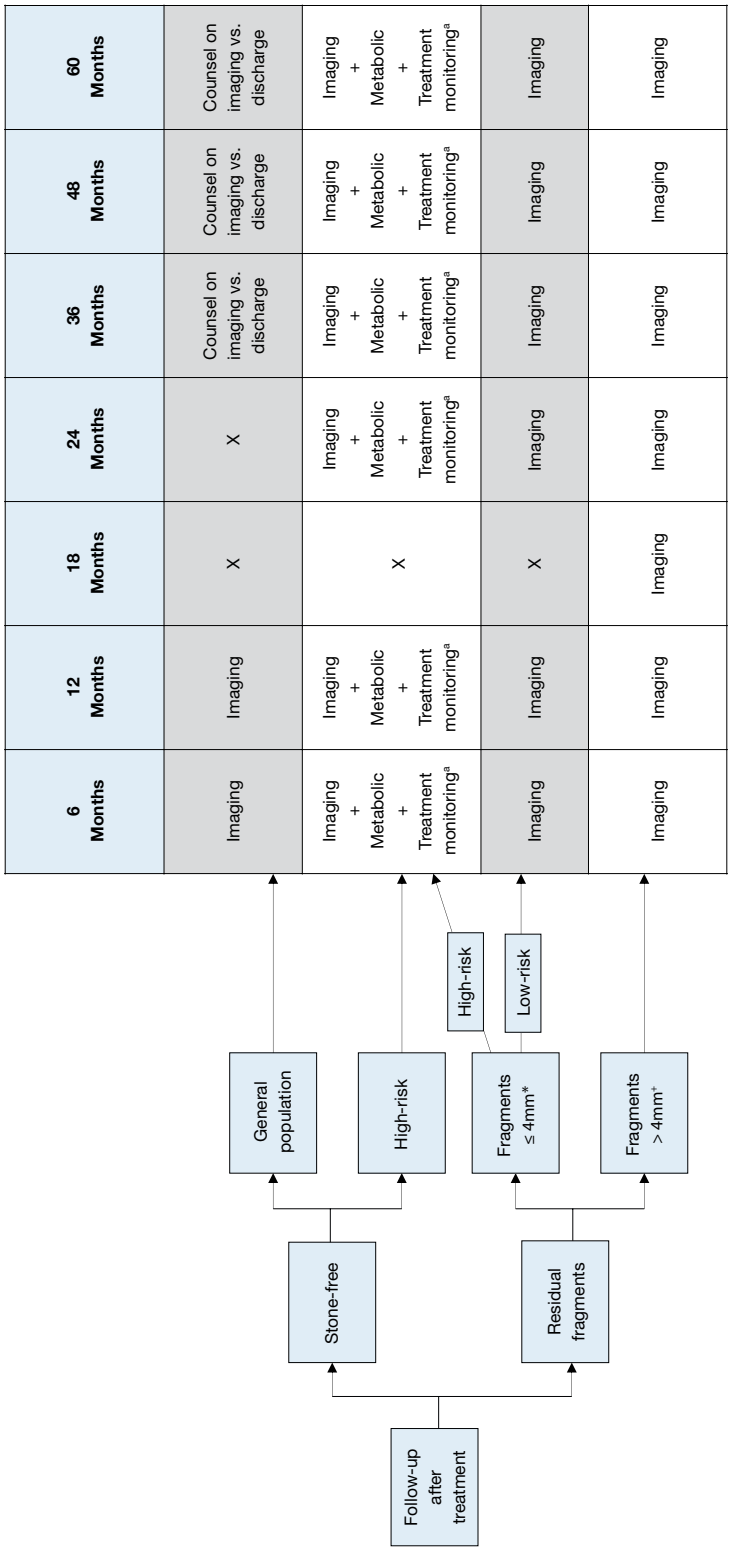
A Panel consensus was reached after extensive discussion of data regarding frequency of follow-up. In stone-free general population, the vast majority of patients remained stone-free during the first year, in contrast with patients with metabolic abnormalities not under targeted medical treatment < 40% were stone-free after three years of follow-up. Therefore, a more extensive follow-up is proposed for patients with metabolic abnormalities. Patients with small residual fragments ≤ 4 mm, showed a spontaneous expulsion at 17.9-46.5% and growth rate at 10.1-40.7% during the first year, while patients with larger fragments (> 4 mm) had only 9% of spontaneous expulsion at three years. Therefore, patients with small ≤ 4 mm, asymptomatic fragments should be followed-up or scheduled for an intervention according to patient preference, while those with larger stones should primarily be offered re-intervention. Proposed imaging consists of plain X-ray KUB and/or US, based on stone characteristics and clinicians' preferences. Computed tomography scan should be reserved for symptomatic disease or pre-operative imaging, in order to avoid extensive radiation exposure (Figure 5.2) [676].

Figure 5.1: Follow-up duration of urinary stone patients after treatment



** Not enough data about subgroup analysis of radiolucent and radiopaque stones.*
*** According to patient preference or symptomatic disease.*
**** Patients with diagnosed metabolic abnormalities.*
***** Lifelong follow-up is advised but data are available up to 10 years.*

Figure 5.2: Consensus on follow-up frequency and imaging modality to use after treatment



Stone free = No stone fragments on post-operative imaging (i.e. no stone fragments on CT/KUB/US). High-risk = Known biochemical abnormality (i.e,: hypercalciuria, hypocitraturia, hyperuricosuria, RTA or high-risk stone type such as struvite). Imaging = plain film KUB &/or kidney ultrasonography (KUS) based on clinicians' preference and stone characteristics. Consider CT if patient is symptomatic or if intervention is planned.

** Clinicians may choose the imaging-only pathway in patients with fragments ≤ 2 mm.*

[o] Treatment monitoring for side effects, intolerance, and compliance.

[+] Panel recommends re-intervention however close follow up may be considered for some patients at high risk for re-intervention based on clinicians' preference.

6. BLADDER STONES

6.1 Prevalence, aetiology, and risk factors of bladder stones

Bladder stones constitute only approximately 5% of all urinary tract stones [677] yet are responsible for 8% of urolithiasis-related mortalities in developed nations [678]. The incidence is higher in developing countries [679]. The prevalence of bladder stones is higher in males, with a reported male to female ratio between 10:1 and 4:1 [680, 681]. The age distribution is bimodal: incidence peaks at three years in children in developing countries [680, 682], and 60 years in adulthood [681].

The aetiology of bladder stones is typically multi-factorial [681]. Bladder stones can be classified as primary, secondary, or migratory [683].

Primary or endemic bladder stones occur in the absence of other urinary tract pathology, typically seen in children in areas with poor hydration, recurrent diarrhoea, and a diet deficient in animal protein [684].

Secondary bladder stones occur in the presence of other urinary tract abnormalities, which include bladder outlet obstruction (BOO), neurogenic bladder dysfunction, chronic bacteriuria, foreign bodies (including catheters), bladder diverticula and bladder augmentation or urinary diversion. In adults, BOO is the most common predisposing factor for bladder stone formation and accounts for 45-79% of vesical calculi [681, 685-688].

Migratory bladder stones are those which have passed from the upper urinary tract where they formed and may then serve as a nidus for bladder stone growth. Patients with bladder calculi are more likely to have a history of upper tract stones and risk factors for their formation [689].

A wide range of metabolic urinary abnormalities can pre-dispose to calculi anywhere in the urinary tract, which is covered in more detailed in section 4. Metabolic Evaluation and Recurrence Prevention. There is a paucity of studies on the specific metabolic abnormalities which predispose to bladder stones.

Bladder stones will form in 3-4.7% of men undergoing surgery for benign prostatic obstruction (BPO) [690, 691], 15-36% of spinal cord injury patients [692-694], and 2.2% of patients with long-term catheters [695]. Of 57 men with chronic urinary retention secondary to BPO, the urine of the 30 men with bladder stones had a higher uric acid concentration (2.2 vs. 0.6 mmol/L, $p < 0.01$), lower magnesium (106 vs. 167 mmol/L, $p = 0.01$) and lower pH (5.9 vs. 6.4, $p = 0.02$) than the 27 men without bladder stones [689]. It is therefore likely that patients with these conditions who form bladder stones also have an abnormal urine composition which pre-disposes them to bladder stone formation.

The metabolic abnormalities which pre-dispose patients to form secondary bladder stones are poorly understood. Stone analysis of 86 men with a BPO-related bladder stone demonstrated 42% had calcium-based stones (oxalate, phosphate), 33% had magnesium ammonium phosphate, 10% had mixed stones and 14% had urate stones [681]. Similar findings were reported in more recent studies [696-698] and it is therefore likely that multiple metabolic factors pre-dispose patients to secondary bladder stone formation.

The exact metabolic basis for primary bladder stones is poorly understood and likely multi-factorial. Low urine volume (poor hydration) is the most consistently demonstrable abnormality [699-701]. Twenty-four-hour urine analysis in children with endemic bladder stones is reported in two studies. Of 57 children in Pakistan, 89.5% had hypocitraturia, 49% had a low urine volume, 44% had hyperoxaluria and 42% had hypocalciuria [699]. Of 61 children in India, stone formers had higher urine calcium and uromucoid concentrations than controls [700]. One study from Thailand compared 24-hour urine analyses from children from a rural area with a high prevalence of bladder stones with those from an urban area: rural children had lower urine volumes and, despite equal calcium, oxalate, and uric acid concentrations, crystalluria with uric acid and calcium oxalate crystals was more prevalent in rural children [701].

Table 6.1 Bladder stones classified by aetiology

Type of bladder stone	Primary	Secondary	Migratory
Cause/Associations	Occur in the absence of other urinary tract pathology, typically in children in areas with poor hydration, recurrent diarrhoea, and a diet deficient in animal protein	BOO (e.g., BPO, urethral stricture)	Form in the upper urinary tract, then passed into the bladder where they may be a nidus for stone growth
		Neurogenic bladder dysfunction	
		Chronic bacteriuria	
		Foreign bodies (including catheters)	
		Bladder diverticula	
		Bladder augmentation	
		Urinary diversion	

BOO = bladder outlet obstruction; BPO = benign prostatic obstruction.

6.2 Presentation

The symptoms most commonly associated with bladder stones are urinary frequency, haematuria (which is typically terminal) and dysuria or suprapubic pain, which are worst towards the end of micturition. Sudden movement and exercise may exacerbate these symptoms. Detrusor over-activity is found in over two thirds of adult male patients with vesical calculi and is significantly more common in patients with larger stones (> 4 cm). However, recurrent UTIs may be the only symptom [686, 687].

In children, symptoms may also include pulling of the penis, difficulties in micturition, urinary retention, enuresis and rectal prolapse (resulting from straining due to bladder spasms). Bladder stones may also be an incidental finding in 10% of cases [684, 702].

6.3 Diagnostic evaluation

*6.3.1 **Diagnostic investigations for bladder stones***

Plain X-ray of KUB has a reported sensitivity of 21%-78% for cystoscopically detected bladder stones in adults [686, 703]. Larger (> 2.0 cm) stones are more likely to be radiopaque [703]. However, plain X-ray provides information on radio-opacity which may guide treatment and follow-up (see section 3.2.3 X-ray characteristics, for further information).

Ultrasound has a reported sensitivity and specificity of 20-83% and 98-100%, respectively for the detection of bladder stones in adults [704, 705]. Computed tomography and cystoscopy have a higher sensitivity for detecting bladder stones than US or X-Ray in adults [704, 705]. No study compares cystoscopy and CT for the diagnosis of bladder stones. Cystoscopy has the advantage of detecting other potential causes for a patient's symptoms (e.g., bladder cancer), whilst CT can also assess upper tract urolithiasis (see section 3.2.3 X-ray characteristics) [706] .

There is a paucity of evidence for the investigation of bladder stones, particularly in children [84, 707]. See also section 3.3 Diagnostic evaluation, for further information on diagnostic imaging for urolithiasis. The principle of ALARA should be applied, especially in children [708].

*6.3.2 **Diagnosing the cause of bladder stones***

The cause of the bladder stone should be considered prior to bladder stone treatment as eliminating the underlying cause will reduce recurrence rates [709]. The following should be performed where possible prior to (or at the time of) bladder stone treatment:

- physical examination of external genitalia, peripheral nervous system (including digital rectal examination, peri-anal tone, and sensation in men);
- uroflowmetry and post-void residual urine assessment;
- urine dipstick to include pH ± culture;
- metabolic assessment (see section 3.3.2.3) including: serum (creatinine, (ionised) calcium, uric acid, sodium, potassium, blood cell count);
- urine pH;
- stone analysis: in first-time formers using a valid procedure (X-ray diffraction or infrared spectroscopy).

The following investigations should also be considered for selected patients:

- upper tract imaging (in patients with a history of urolithiasis or loin pain);
- cysto-urethroscopy or urethrogram.

6.4 Disease Management

6.4.1 ***Conservative treatment and Indications for active stone removal***

Migratory bladder stones in adults may typically be left untreated, especially asymptomatic small stones. Rates of spontaneous stone passage are unknown, but data on ureteric stones suggest stones < 1 cm are likely to pass in the absence of BOO, bladder dysfunction or long-term catheterisation (see section 3.4.9 Specific stone management of ureteral stones).

Primary and secondary bladder stones are usually symptomatic and are unlikely to pass spontaneously: active treatment of such stones is usually indicated.

6.4.2 ***Medical management of bladder stones***

There is a paucity of evidence on chemolitholysis of bladder stones. However, guidance on the medical management of urinary tract stones in section 3.4.9 Specific stone management of ureteral stones, can be applied to urinary stones in all locations. Uric acid stones can be dissolved by oral urinary alkalinisation when a PH > 6.5 is consistently achieved, typically using an alkaline citrate or sodium bicarbonate. Regular monitoring is required during therapy (see section 3.4.4 Chemolysis). Irrigation chemolysis is also possible using a catheter; however, this is time consuming and may cause chemical cystitis and is therefore not commonly employed [141, 710].

6.4.3 ***Bladder stone interventions***

Minimally invasive techniques for the removal of bladder stones have been widely adopted to reduce the risk of complications and shorten hospital stay and convalescence. Bladder stones can be treated with open, laparoscopic, robotic assisted laparoscopic, endoscopic (transurethral or percutaneous) surgery or ESWL [4].

6.4.3.1 Suprapubic cystolithotomy

Open suprapubic cystolithotomy is very effective but is associated with a need for catheterisation and longer hospital stay in both adults and children compared to all other stone removal modalities [360]. In children, a non-randomised study found that, if the bladder was closed meticulously in two layers, “tubeless” (drain-less and catheter-less) cystolithotomy was associated with a significantly shorter length of hospital stay compared with traditional cystolithotomy, without significant differences regarding late or intra-operative complications provided that children with prior UTI, recurrent stones, or with previous surgery for anorectal malformation (or other relevant surgery) were excluded [711].

6.4.3.2 Transurethral cystolithotripsy

In both adults and children, transurethral cystolithotripsy provides high SFRs and appears to be safe, with a very low-risk of unplanned procedures and major post-operative and late complications [4].

6.4.3.2.1 Transurethral cystolithotripsy in adults

In adults, meta-analysis of four RCTs including 409 patients demonstrated that transurethral cystolithotripsy has a shorter hospital stay and convalescence with less pain, but equivalent SFR and complications compared to percutaneous cystolithotripsy [4]. Transurethral cystolithotripsy with a nephroscope was quicker than percutaneous cystolithotripsy in three RCTs, although transurethral cystolithotripsy with a cystoscope was slower than percutaneous cystolithotripsy [4].

Rates of urethral strictures following transurethral procedures were not robustly reported: studies report rates between 2.9% and 19.6% during a follow up of 12 – 24 months [4, 696, 712].

One small RCT demonstrated a shorter duration of catheterisation, hospital stay and procedure with transurethral cystolithotripsy than open cystolithotomy with similar SFR [4]. Meta-analysis of four RCTs found shorter procedure duration for transurethral cystolithotripsy using a nephroscope vs. cystoscope with similar SFRs, hospital stay, convalescence, pain, and complications [4, 696, 713-715]. Two retrospective studies (n=188) reported that using a resectoscope or nephroscope was associated with a shorter procedure duration ($p < 0.05$) than a cystoscope for transurethral cystolithotripsy [716, 717]. This suggests that transurethral cystolithotripsy is quicker when using a continuous flow instrument.

6.4.3.2.1.1 Lithotripsy modalities used during transurethral cystolithotripsy in adults

When considering lithotripsy modalities for transurethral cystolithotripsy, the Panel’s systematic review found very low-quality evidence from five non-randomised studies (n=385) which found no difference in SFR between modalities (mechanical, laser, pneumatic, ultrasonic, electrohydraulic lithotripsy [EHL] or washout alone) [4]. Unplanned procedures and major post-operative complications were low-rate events and were not significantly different between lithotripsy modalities, although one non-randomised study (NRS) suggested these might be

higher with EHL or mechanical lithotripsy than pneumatic or ultrasonic lithotripsy [718]. All outcomes had very low-quality of evidence (GRADE) [4]. High powered lasers seem to reduce lithotripsy time. Laser lithotripsy was faster than pneumatic lithotripsy (MD 16.6 minutes; CI: 23.51-9.69, p < 0.0001) in one NRS (n=62); however, a laser was used with a resectoscope and the pneumatic device with a cystoscope [719]. Continuous vs. intermittent irrigating instrument may affect the operation time more significantly than the choice of lithotripsy device [4].

6.4.3.2.1.2 Transurethral cystolithotripsy in children
In children, three NRS suggest that transurethral cystolithotripsy has a shorter hospital stay and catheterisation time than open cystolithotomy, but similar stone-free and complication rates [4, 720]. One small quasi RCT found a shorter procedure time using laser vs. pneumatic lithotripsy for < 1.5 cm bladder stones with no difference in SFR or other outcomes [4, 721].

6.4.3.3 Percutaneous cystolithotripsy
6.4.3.3.1 Percutaneous cystolithotripsy in adults:
One NRS found a shorter duration of procedure and catheterisation and less blood loss for percutaneous, compared with open surgery in adult male patients with urethral strictures; all patients in both groups were rendered stone-free [698].

Meta-analysis of four RCTs comparing transurethral and percutaneous cystolithotripsy found a shorter hospital stay for transurethral cystolithotripsy over percutaneous surgery. Transurethral cystolithotripsy was quicker when using a nephroscope. There were no significant differences in SFRs, major post-operative complications or re-treatment [4].

6.4.3.3.2 Percutaneous cystolithotripsy in children:
In children, three NRS suggest that percutaneous cystolithotripsy has a shorter hospital stay and catheterisation time, but a longer procedure duration and more peri-operative complications than open cystolithotripsy; SFRs were similar [4, 702, 720].

Two small NRS compared percutaneous and transurethral cystolithotripsy and both found similar SFRs, but that transurethral surgery offers a shorter duration of catheterisation and hospital stay [702, 720]. One small NRS found a non-significant increased risk of unplanned procedures (within 30 days of primary procedure) and major post-operative complications for percutaneous operations compared with transurethral procedures; however, age and stone size determined which intervention children underwent and all patients were rendered stone-free [702]. Urethral stricture rates were not robustly compared in either study.

6.4.3.4 Extracorporeal shock wave lithotripsy
Extracorporeal SWL is the least invasive therapeutic procedure [4].

6.4.3.4.1 Shock wave lithotripsy in adults
In adults, one RCT compared SWL with transurethral cystolithotripsy in 100 patients with ≤ 2 cm bladder stones presenting with acute urinary retention. Stone free rate after one SWL session favoured transurethral cystolithotripsy (86% vs. 98%, p=0.03); however, following up to three sessions of SWL, there was no significant difference in SFR (94% vs. 98%, p=0.3) [4, 722].

Two NRS compared transurethral cystolithotripsy vs. SWL and found no significant difference in SFR (97.0% vs. 93.9%, p=0.99, 97.7% vs. 89.7% p=0.07) despite larger stones in transurethral cystolithotripsy patients (4.2 vs. 2.5 cm, p=0.014; and 3.6 vs. 2.6 cm [p value not reported]) [723, 724].

Length of hospital stay appeared to favour SWL in all three studies (0 vs. 1 day, 4.8 vs. 0 days, p=0.02, 0.8 vs. 2.4 days, respectively) [722-724]. No significant differences in major post-operative or intra-operative complications were reported in any study [722-724].

One NRS compared SWL vs. open cystolithotomy in just 43 patients. Stone sizes were not comparable (2.5 vs. 7.4 cm, p < 0.001). Stone-free rates were not significantly different (93.9% vs. 100%, p=0.50). Length of stay favoured SWL. There was no significant difference in intra-operative or major post-operative complications [723].

6.4.3.4.2 Shock wave lithotripsy in children
One large NRS found lower SFR for SWL than both transurethral cystolithotripsy and open cystolithotomy,

despite treating smaller stones with SWL. However, the length of hospital stays favoured SWL over open cystolithotomy, although this appeared to be comparable between SWL and transurethral cystolithotripsy [725].

6.4.3.5 Laparoscopic cystolithotomy

Laparoscopic cystolithotomy has been described in adults and is typically performed in combination with simple prostatectomy using either traditional laparoscopy or with robotic assistance [726, 727]. A SR found no studies comparing laparoscopic surgery with other procedures [4].

6.4.4 ***Treatment for bladder stones secondary to bladder outlet obstruction in adult men***

Bladder stones in men aged over 40 years may be caused by BPO, the management of which should also be considered. Bladder stones were traditionally an indication for a surgical intervention for BPO: a doctrine which has been questioned by recent studies. One prospective study reports urodynamics (cystometrogram) findings in 46 men aged > 60 years before and after bladder stone treatment [687]. Only 51% of men had BOO while 10% had detrusor under-activity. Eighteen percent of men had a completely normal urodynamic study and 68% had detrusor over-activity. There was no significant difference between pre- and post-bladder stone removal urodynamic findings [687].

One NRS compared 64 men undergoing transurethral cystolithotripsy with either transurethral resection of prostate (TURP) or medical management for BPO (α-blocker with or without 5-alpha reductase inhibitor). After 28 months follow-up, no men on medication had had a recurrence, but 34% underwent TURP: a high post-void residual urine volume predicted the need for subsequent TURP [728]. Another observational study of 23 men undergoing cystolithotripsy and commencing medical management for BPO found 22% developed a BPO related complication, including 17% who had recurrent stones [709].

Large studies support the safety of performing BPO and bladder stone procedures during the same operation with no difference in major complications compared to a BPO procedure alone [729-731]. An observational study on 2,271 patients undergoing TURP found no difference in complications except UTIs, which occurred slightly more frequently in patients with simultaneously treated bladder stones: 0% vs. 0.6%, p=0.044 [729]. An observational study of 321 men undergoing Holmium laser enucleation of the prostate (HoLEP) found a higher rate of early post-operative incontinence (26.8% vs. 12.5%, p=0.03) in men having concomitant transurethral cystolithotripsy, but no difference in long-term continence rates [731]. Another larger multicenter observational study of 963 patients undergoing HoLEP found no significant differences in frequency of complications in patients with (n=54 (5.6%)) or without concomitant transurethral cystolithotripsy [732].

6.4.5 ***Special situations***

6.4.5.1 Neurogenic bladder and stone formation

Patients with a neurogenic bladder secondary to spinal cord injury or myelomeningocele are at increased risk of forming bladder stones. Within eight to ten years, 15-36% of patients with spinal cord injury will develop a bladder stone [692-694]. The absolute annual risk of stone formation in spinal cord injury patients with an indwelling catheter is 4% compared with 0.2% for those voiding with clean intermittent self-catheterisation (CISC) [733].

A study of 2,825 spinal cord injury patients over eight years found a 3.3% incidence of bladder stones: 2% with CISC, 6.6% with indwelling urethral catheter, 11% with a suprapubic catheter and 1.1% in patients voiding using reflex micturition [734]. However, another study of 457 spinal cord injury patients for six months found no difference in bladder stones between urethral and suprapubic catheterisation [733]. Spinal cord injury patients with an indwelling urethral catheter are six times more likely to develop bladder stones than patients with normal micturition [694, 734].

The risk of stone recurrence after complete removal in spinal cord injury patients is 16% per year [733]. A RCT of 78 spinal cord injury patients who perform CISC found a significant reduction in bladder stone formation when twice weekly manual bladder irrigations were performed for six months (49% vs. 0%, p= < 0.0001), as well as less symptomatic UTIs (41% vs. 8%; p=0.001) [735]. However, this study excluded patients who developed autonomic dysreflexia during bladder irrigations. The irrigation volume used was not reported.

6.4.5.2 Bladder Augmentation

The incidence of vesical calculus formation after bladder augmentation is 2-44% in adults [736-745], and 4-53% in children [745-759]. Following cystoplasty, stones form after 24-31 months in adults [737, 739, 744], and after 25-68 months in children [750, 753, 754, 758, 760-762]. The reported cumulative incidence of bladder stone formation after ten years is 28-36% and after twenty years is 41% [745, 763].

Risk factors for bladder stone formation after augmentation include excess mucus production, incomplete bladder emptying, non-compliance with CIC or bladder irrigations, bacteriuria or urinary tract infections (due to urease-producing bacteria), foreign bodies (including staples, mesh, non-absorbable sutures), drainage by vesico-entero-cystostomy (Mitrofanoff or Monti) [436, 737, 740, 742, 743, 750, 754, 757, 763] and voiding by CISC compared with those voiding spontaneously [741]. Gastric segment augmentation confers a lower risk of bladder stones than ileal or colonic segment cystoplasty [746, 750, 754, 757].

In previous stone formers, the rate of recurrence is 15-44% in adults [737-739, 741, 744], and 19-56% in children [436, 745, 746, 750, 752-755, 757, 762]. The risk of recurrence is greatest during the first two years, at about 12% per patient per year, with the risk decreasing with time [762].

Daily, or three-times-weekly bladder irrigations reduce the incidence of bladder stones following bladder augmentation or continent urinary diversion [436, 740]. A randomised study found that daily bladder irrigation with 240 mL of saline reduced stone recurrences ($p = < 0.0002$, $p = 0.0152$) and symptomatic UTIs ($p < 0.0001$, $p < 0.0001$) compared to 60mL or 120mL [740]. The frequency of bladder irrigations required is unclear.

6.4.5.3 Urinary diversion

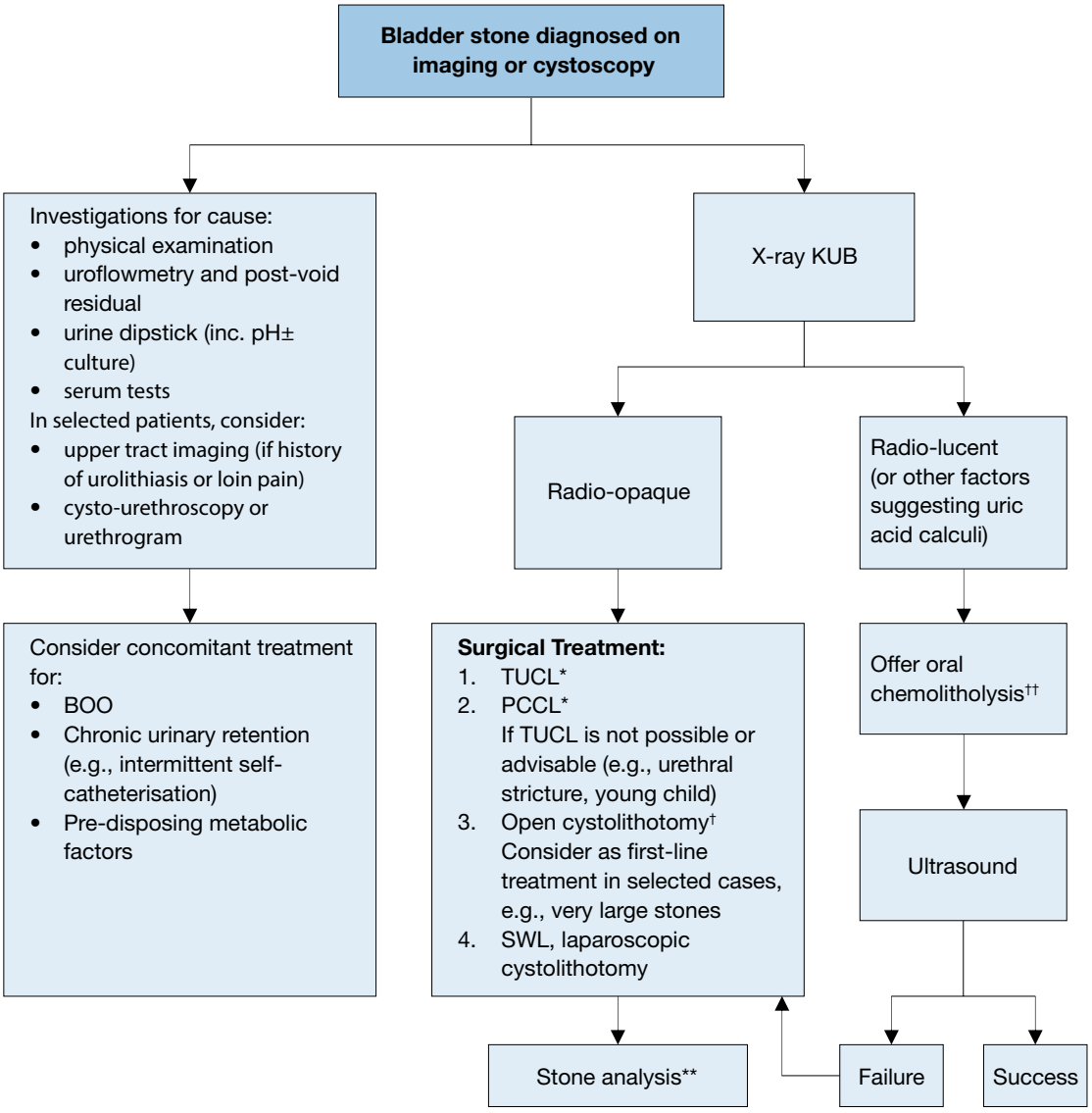
The incidence of stone formation after urinary diversion with an ileal or colon conduit is 0-3% [764, 765]. The incidence of stone formation is 0-34% in orthotopic ileal neobladders (Hautmann, hemi-Kock, Studer, T-pouch or w-neobladder) [741, 765-774], and 4-6% in orthotopic sigmoid neobladders (Reddy) [770, 775]. The risk of pouch stone formation is 4-43% in adults with an ileocaecal continent cutaneous urinary diversion (Indiana, modified Indiana, Kock or Mainz I) [428, 741, 764, 765, 773, 776]. The average interval from construction of the urinary diversion to stone detection is 71-99 months [769, 777]. In children, the incidence of neobladder stone formation is 30% after Mainz II diversion (rectosigmoid reservoir) [747], and 27% after Kock ileal reservoir construction [759].

6.4.5.4 Treatment of stones in patients with bladder augmentation or urinary diversion

Stones may be removed by open or endoscopic surgery in patients with bladder augmentation or diversion [752]. However, often access cannot be obtained through a continent vesico-entero-cystostomy without damaging the continence apparatus; hence a percutaneous or open approach is typically preferred [752].

No studies comparing outcomes following procedures for stones in reconstructed or augmented bladders were found. Two observational studies indicate that percutaneous lithotomy can be safely performed with US or CT guidance in patients with reconstructed or augmented bladders [778, 779] and is proposed to offer similar advantages over open surgery to those for percutaneous native bladder surgery. Stone recurrence after successful removal has been reported to be 10-42% [778, 779], but appears to be unrelated to the modality used for stone removal [744, 750, 754, 755, 757, 762].

Figure 6.1 Management of bladder stones



BOO = bladder outlet obstruction, TUCL = trans-urethral cystolithotripsy, PCCL = percutaneous cystolithotripsy, SWL = shock-wave lithotripsy.

** Lithotripsy modality at surgeon's discretion (e.g., mechanical, laser, pneumatic, ultrasonic).*

† Prefer "tubeless" procedure (without placing a catheter or drain) for children with primary bladder stones and no prior infection, surgery, or bladder dysfunction where open cystolithotomy is indicated.

*** Stone analysis should be sent for all first-time stone formers and in patients who develop a recurrence under pharmacological prevention, early recurrence after interventional therapy with complete stone clearance or late recurrence after a prolonged stone-free period.*

†† Use an alkaline citrate or sodium bicarbonate with frequent urine pH monitoring and dose titration to achieve a consistent pH > 6.5.

6.5 Bladder stones follow-up

There are no studies examining the merits of differing follow-up modalities or frequencies following conservative, medical, or operative treatment of bladder stones in adults or children. Identification and prevention of the cause of bladder stone formation will be crucial to prevent recurrence (see section 6.3.2 Diagnosing the cause of bladder stones).

In adults, there is a paucity of evidence on dietary modification or medical treatment for the prevention of bladder stone recurrence. Recommendations in the EAU Guideline on Urolithiasis, based on evidence from upper tract stones, constitutes the best available recommendations, especially for migratory bladder stones (see section 4. Metabolic Evaluation and Recurrence Prevention).

Where it is possible to address the cause of secondary bladder stones (e.g., treatment of BPO), it is unclear whether metabolic intervention would offer any significant additional benefit in preventing stone recurrence. However, especially where the secondary cause cannot be addressed (e.g., indwelling catheter, neuropathic bladder, bladder augmentation or urinary diversion); metabolic interventions are likely to reduce bladder stone recurrence rates.

Regular bladder irrigation reduces the chances of bladder stone recurrence in adults and children with bladder augmentation or continent cutaneous urinary diversion and adults with spinal cord injury who perform CISC (see section 6.4.5 Special Situations) [735, 740, 765].

In children with primary (endemic) bladder stones maintenance of hydration, avoidance of diarrhoea and a mixed cereal diet with milk and Vitamins A and B supplements, with the addition of eggs, meat, and boiled cows' milk after one year of age are recommended to prevent recurrence [699].

Finally, there are contradictory reports on a possible association between bladder calculi and future development of bladder cancer [780-782]. The need for follow-up with regular cystoscopy therefore remains controversial.

Summary of evidence	**LE**
The incidence of bladder stones peaks at three years in children (endemic/primary stones in developing countries) and 60 years in adults.	2c
The aetiology of bladder stones is typically multi-factorial. Bladder stones can be classified as primary (endemic), secondary (associated with lower urinary tract abnormalities e.g., BPO, neuropathic bladder, foreign body, chronic bacteriuria) or migratory (having formed in the upper tract).	4
In adults, BOO is the most common pre-disposing factor for bladder stone formation.	2C
Of men undergoing surgery for BPO, 3-4.7% form bladder stones.	2b
Metabolic abnormalities are also likely to contribute to bladder stone formation in patients with secondary bladder stones.	2b
Primary (endemic) bladder stones typically occur in children in areas with poor hydration, recurrent diarrhoea, and a diet deficient in animal protein. The following measures are proposed to reduce their incidence: maintenance of hydration, avoidance of diarrhoea, and a mixed cereal diet with milk and Vitamins A and B supplements; with the addition of eggs, meat, and boiled cows' milk after one year of age.	5
In adults, US has a sensitivity of 20-83% for diagnosing bladder stones.	2b
In adults, X-ray-KUB has a sensitivity of 21-78%; sensitivity increases with stone size.	2b
Computed tomography has a higher sensitivity than US for the detection of bladder stones.	2b
Cystoscopy has a higher sensitivity than X-ray-KUB or US for the detection of bladder stones.	2b
Endoscopic bladder stone treatments (trans-urethral or percutaneous) are associated with comparable SFRs, but a shorter length of hospital stay, duration of procedure and duration of catheterisation compared to open cystolithotomy in adults.	1a
Stone-free rates are lower in patients treated with SWL than those treated with open or endoscopic procedures in both adults and children.	2a
Transurethral cystolithotripsy is associated with a shorter length of hospital stay, less pain and a shorter convalescence period than percutaneous cystolithotripsy in adults.	1b
Transurethral cystolithotripsy with a nephroscope is quicker than when using a cystoscope with no difference in SFR in adults.	1a
Transurethral cystolithotripsy with a resectoscope is quicker than when using a cystoscope with no difference in SFR in adults.	2a
Mechanical, pneumatic and laser appear equivalent lithotripsy modalities for use in endoscopic bladder stone treatments in adults and children.	2a
Open cystolithotomy without a retropubic drain or urethral catheter ("tubeless") is associated with a shorter length of hospital stay than traditional cystolithotomy and can be performed safely in children with primary stones and no prior bladder surgery or infections.	2b
Bladder stone removal with concomitant treatment for BOO is associated with no significant difference in major post-operative complications when compared to BOO treatment alone in adults. However, concomitant bladder stone treatment does increase the rates of short-term post-operative incontinence and UTI.	2b

The incidence of bladder stone formation in spinal cord injury patients is 15-36% after eight to ten years. The absolute annual risk of stone formation in spinal cord injury patients is significantly higher with an indwelling catheter compared to those voiding with CISC or spontaneously.	2b
The incidence of bladder stone formation after bladder augmentation or vesico-entero-cystostomy is between 2-53% in adults and children.	2b
Urinary diversion including orthotopic ileal neobladders, ileocaecal continent cutaneous urinary diversion and rectosigmoid reservoirs is associated with urinary reservoir stone formation in 0-43%.	2b
The risk of bladder stone formation in spinal cord injury, bladder augmentation or continent urinary diversion patients is reduced by performing regular bladder irrigation.	2b

Recommendations	**Strength rating**
Use ultrasound (US) as first-line imaging with symptoms suggestive of a bladder stone.	Strong
Use cystoscopy or computed tomography (CT), or kidney-ureter-bladder X-Ray (KUB) to investigate adults with persistent symptoms suggestive of a bladder stone if US is negative.	Strong
Use X-Ray KUB for adults with confirmed bladder stones to guide treatment options and follow-up.	Weak
All patients with bladder stones should be examined and investigated for the cause of bladder stone formation, including: • uroflowmetry and post-void residual; • urine dipstick, pH, ± culture; • metabolic assessment and stone analysis (see sections 3.3.2.3 and 4.1 for further details). In selected patients, consider: • upper tract imaging (in patients with a history of urolithiasis or loin pain); • cysto-urethroscopy or urethrogram.	Weak
Offer oral chemolitholysis for radiolucent or known uric acid bladder stones in adults.	Weak
Offer adults with bladder stones transurethral cystolithotripsy where possible.	Strong
Perform transurethral cystolithotripsy with a continuous flow instrument in adults (e.g., nephroscope or resectoscope) where possible.	Weak
Offer adults percutaneous cystolithotripsy where transurethral cystolithotripsy is not possible or advisable.	Strong
Suggest open cystolithotomy as an option for very large bladder stones in adults and children.	Weak
Offer children with bladder stones transurethral cystolithotripsy where possible.	Weak
Offer children percutaneous cystolithotripsy where transurethral cystolithotripsy is not possible or is associated with a high risk of urethral stricture (e.g., young children, previous urethral reconstruction, and spinal cord injury).	Weak
Open, laparoscopic, and extracorporeal shock wave lithotripsy are alternative treatments where endoscopic treatment is not advisable in adults and children.	Weak
Prefer “tubeless” procedure (without placing a catheter or drain) for children with primary bladder stones and no prior infection, surgery, or bladder dysfunction where open cystolithotomy is indicated.	Weak
Perform procedures for the stone and underlying bladder outlet obstruction (BOO) simultaneously in adults with bladder stones secondary to BOO, where possible.	Strong
Individualise imaging follow up for each patient as there is a paucity of evidence. Factors affecting follow up will include: • whether the underlying functional predisposition to stone formation can be treated (e.g., transurethral resection of the prostate [TURP]); • metabolic risk.	Weak
Recommend regular irrigation therapy with saline solution to adults and children with bladder augmentation, continent cutaneous urinary reservoir or neuropathic bladder dysfunction, and no history of autonomic dysreflexia, to reduce the risk of stone recurrence.	Weak

7. REFERENCES

1. Skolarikos, A., *et al*. Metabolic evaluation and recurrence prevention for urinary stone patients: EAU guidelines. Eur Urol, 2015. 67: 750. https://pubmed.ncbi.nlm.nih.gov/25454613/
2. Turk, C., *et al*. EAU Guidelines on Diagnosis and Conservative Management of Urolithiasis. Eur Urol, 2016. 69: 468. https://pubmed.ncbi.nlm.nih.gov/26318710/
3. Turk, C., *et al*. EAU Guidelines on Interventional Treatment for Urolithiasis. Eur Urol, 2016. 69: 475. https://pubmed.ncbi.nlm.nih.gov/26344917/
4. Donaldson, J.F., *et al*. Treatment of Bladder Stones in Adults and Children: A Systematic Review and Meta-analysis on Behalf of the European Association of Urology Urolithiasis Guideline Panel. Eur Urol, 2019. 76: 352. https://pubmed.ncbi.nlm.nih.gov/31311676/
5. Guyatt, G.H., *et al*. What is "quality of evidence" and why is it important to clinicians? BMJ, 2008. 336: 995. https://pubmed.ncbi.nlm.nih.gov/18456631/
6. Guyatt, G.H., *et al*. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. BMJ, 2008. 336: 924. https://pubmed.ncbi.nlm.nih.gov/18436948/
7. Phillips, B., *et al*. Oxford Centre for Evidence-based Medicine Levels of Evidence. Updated by Jeremy Howick (March 2009). 2009. https://www.cebm.ox.ac.uk/resources/levels-of-evidence/oxford-centre-for-evidence-based-medicine-levels-of-evidence-march-2009
8. Guyatt, G.H., *et al*. Going from evidence to recommendations. BMJ, 2008. 336: 1049. https://pubmed.ncbi.nlm.nih.gov/18467413/
9. Trinchieri A. *et al*. Epidemiology, In: Stone Disease, K.S. C.P. Segura JW, Pak CY, Preminger GM, Tolley D., Editor. 2003, Health Publications: Paris.
10. Stamatelou, K.K., *et al*. Time trends in reported prevalence of kidney stones in the United States: 1976-1994. Kidney Int, 2003. 63: 1817. https://pubmed.ncbi.nlm.nih.gov/12675858/
11. Hesse, A., *et al*. Study on the prevalence and incidence of urolithiasis in Germany comparing the years 1979 vs. 2000. Eur Urol, 2003. 44: 709. https://pubmed.ncbi.nlm.nih.gov/14644124/
12. Sanchez-Martin, F.M., *et al*. [Incidence and prevalence of published studies about urolithiasis in Spain. A review]. Actas Urol Esp, 2007. 31: 511. https://pubmed.ncbi.nlm.nih.gov/17711170/
13. Zhe, M., *et al*. Nephrolithiasis as a risk factor of chronic kidney disease: a meta-analysis of cohort studies with 4,770,691 participants. Urolithiasis, 2017. 45: 441. https://pubmed.ncbi.nlm.nih.gov/27837248/
14. Wang, L., *et al*. Association Study of Reported Significant Loci at 5q35.3, 7p14.3, 13q14.1 and 16p12.3 with Urolithiasis in Chinese Han Ethnicity. Sci Rep, 2017. 7: 45766. https://pubmed.ncbi.nlm.nih.gov/28361944/
15. Leusmann, D.B. Whewellite, weddellite and company: where do all the strange names originate? BJU Int, 2000. 86: 411. https://pubmed.ncbi.nlm.nih.gov/10971263/
16. Strohmaier, W.L. Course of calcium stone disease without treatment. What can we expect? Eur Urol, 2000. 37: 339. https://pubmed.ncbi.nlm.nih.gov/10720863/
17. Ferraro, P.M., *et al*. Risk of recurrence of idiopathic calcium kidney stones: analysis of data from the literature. J Nephrol, 2017. 30: 227. https://pubmed.ncbi.nlm.nih.gov/26969574/
18. Keoghane, S., *et al*. The natural history of untreated renal tract calculi. BJU Int, 2010. 105: 1627. https://pubmed.ncbi.nlm.nih.gov/20438563/
19. Straub, M., *et al*. Diagnosis and metaphylaxis of stone disease. Consensus concept of the National Working Committee on Stone Disease for the upcoming German Urolithiasis Guideline. World J Urol, 2005. 23: 309. https://pubmed.ncbi.nlm.nih.gov/16315051/

20. Pawar, A.S., *et al*. Incidence and characteristics of kidney stones in patients with horseshoe kidney: A systematic review and meta-analysis. Urol Ann, 2018. 10: 87.
https://pubmed.ncbi.nlm.nih.gov/29416282/
21. Dissayabutra, T., *et al*. Urinary stone risk factors in the descendants of patients with kidney stone disease. Pediatr Nephrol, 2018. 33: 1173.
https://pubmed.ncbi.nlm.nih.gov/29594505/
22. Hu, H., *et al*. Association between Circulating Vitamin D Level and Urolithiasis: A Systematic Review and Meta-Analysis. Nutrients, 2017. 9.
https://pubmed.ncbi.nlm.nih.gov/28335477/
23. Geraghty, R.M., *et al*. Worldwide Impact of Warmer Seasons on the Incidence of Renal Colic and Kidney Stone Disease: Evidence from a Systematic Review of Literature. J Endourol, 2017. 31: 729.
https://pubmed.ncbi.nlm.nih.gov/28338351/
24. Guo, Z.L., *et al*. Association between cadmium exposure and urolithiasis risk: A systematic review and meta-analysis. Medicine (Baltimore), 2018. 97: e9460.
https://pubmed.ncbi.nlm.nih.gov/29505519/
25. Hesse, A.T., *et al*. (Eds.), Urinary Stones, Diagnosis, Treatment and Prevention of Recurrence. 3rd edition. 2009, Basel.
26. Basiri, A., *et al*. Familial relations and recurrence pattern in nephrolithiasis: new words about old subjects. Urol J, 2010. 7: 81.
https://pubmed.ncbi.nlm.nih.gov/20535692/
27. Goldfarb, D.S., *et al*. A twin study of genetic and dietary influences on nephrolithiasis: a report from the Vietnam Era Twin (VET) Registry. Kidney Int, 2005. 67: 1053.
https://pubmed.ncbi.nlm.nih.gov/15698445/
28. Asplin, J.R., *et al*. Hyperoxaluria in kidney stone formers treated with modern bariatric surgery. J Urol, 2007. 177: 565.
https://pubmed.ncbi.nlm.nih.gov/17222634/
29. Gonzalez, R.D., *et al*. Kidney stone risk following modern bariatric surgery. Curr Urol Rep, 2014. 15: 401.
https://pubmed.ncbi.nlm.nih.gov/24658828/
30. Rendina, D., *et al*. Metabolic syndrome and nephrolithiasis: a systematic review and meta-analysis of the scientific evidence. J Nephrol, 2014. 27: 371.
https://pubmed.ncbi.nlm.nih.gov/24696310/
31. Dell'Orto, V.G., *et al*. Metabolic disturbances and renal stone promotion on treatment with topiramate: a systematic review. Br J Clin Pharmacol, 2014. 77: 958.
https://pubmed.ncbi.nlm.nih.gov/24219102/
32. Mufti, U.B., *et al*. Nephrolithiasis in autosomal dominant polycystic kidney disease. J Endourol, 2010. 24: 1557.
https://pubmed.ncbi.nlm.nih.gov/20818989/
33. Chen, Y., *et al*. Current trend and risk factors for kidney stones in persons with spinal cord injury: a longitudinal study. Spinal Cord, 2000. 38: 346.
https://pubmed.ncbi.nlm.nih.gov/10889563/
34. Hara, A., *et al*. Incidence of nephrolithiasis in relation to environmental exposure to lead and cadmium in a population study. Environ Res, 2016. 145: 1.
https://pubmed.ncbi.nlm.nih.gov/26613344/
35. Gambaro, G., *et al*. The Risk of Chronic Kidney Disease Associated with Urolithiasis and its Urological Treatments: A Review. J Urol, 2017. 198: 268.
https://pubmed.ncbi.nlm.nih.gov/28286070/
36. Leusmann, D.B., *et al*. Results of 5,035 stone analyses: a contribution to epidemiology of urinary stone disease. Scand J Urol Nephrol, 1990. 24: 205.
https://pubmed.ncbi.nlm.nih.gov/2237297/
37. Kim, S.C., *et al*. Cystine calculi: correlation of CT-visible structure, CT number, and stone morphology with fragmentation by shock wave lithotripsy. Urol Res, 2007. 35: 319.
https://pubmed.ncbi.nlm.nih.gov/17965956/
38. Wimpissinger, F., *et al*. The silence of the stones: asymptomatic ureteral calculi. J Urol, 2007. 178: 1341.
https://pubmed.ncbi.nlm.nih.gov/17706721/
39. Ray, A.A., *et al*. Limitations to ultrasound in the detection and measurement of urinary tract calculi. Urology, 2010. 76: 295.
https://pubmed.ncbi.nlm.nih.gov/20206970/

40. Smith-Bindman, R., *et al*. Ultrasonography versus computed tomography for suspected nephrolithiasis. N Engl J Med, 2014. 371: 1100.
https://pubmed.ncbi.nlm.nih.gov/25229916/
41. Heidenreich, A., *et al*. Modern approach of diagnosis and management of acute flank pain: review of all imaging modalities. Eur Urol, 2002. 41: 351.
https://pubmed.ncbi.nlm.nih.gov/12074804/
42. Kennish, S.J., *et al*. Is the KUB radiograph redundant for investigating acute ureteric colic in the non-contrast enhanced computed tomography era? Clin Radiol, 2008. 63: 1131.
https://pubmed.ncbi.nlm.nih.gov/18774360/
43. Worster, A., *et al*. The accuracy of noncontrast helical computed tomography versus intravenous pyelography in the diagnosis of suspected acute urolithiasis: a meta-analysis. Ann Emerg Med, 2002. 40: 280.
https://pubmed.ncbi.nlm.nih.gov/12192351/
44. Wu, D.S., *et al*. Indinavir urolithiasis. Curr Opin Urol, 2000. 10: 557.
https://pubmed.ncbi.nlm.nih.gov/11148725/
45. El-Nahas, A.R., *et al*. A prospective multivariate analysis of factors predicting stone disintegration by extracorporeal shock wave lithotripsy: the value of high-resolution noncontrast computed tomography. Eur Urol, 2007. 51: 1688.
https://pubmed.ncbi.nlm.nih.gov/17161522/
46. Patel, T., *et al*. Skin to stone distance is an independent predictor of stone-free status following shockwave lithotripsy. J Endourol, 2009. 23: 1383.
https://pubmed.ncbi.nlm.nih.gov/19694526/
47. Zarse, C.A., *et al*. CT visible internal stone structure, but not Hounsfield unit value, of calcium oxalate monohydrate (COM) calculi predicts lithotripsy fragility in vitro. Urol Res, 2007. 35: 201.
https://pubmed.ncbi.nlm.nih.gov/17565491/
48. Kluner, C., *et al*. Does ultra-low-dose CT with a radiation dose equivalent to that of KUB suffice to detect renal and ureteral calculi? J Comput Assist Tomogr, 2006. 30: 44.
https://pubmed.ncbi.nlm.nih.gov/16365571/
49. Caoili, E.M., *et al*. Urinary tract abnormalities: initial experience with multi-detector row CT urography. Radiology, 2002. 222: 353.
https://pubmed.ncbi.nlm.nih.gov/11818599/
50. Van Der Molen, A.J., *et al*. CT urography: definition, indications and techniques. A guideline for clinical practice. Eur Radiol, 2008. 18: 4.
https://pubmed.ncbi.nlm.nih.gov/17973110/
51. Thomson, J.M., *et al*. Computed tomography versus intravenous urography in diagnosis of acute flank pain from urolithiasis: a randomized study comparing imaging costs and radiation dose. Australas Radiol, 2001. 45: 291.
https://pubmed.ncbi.nlm.nih.gov/11531751/
52. Smith-Bindman, R., *et al*. Computed Tomography Radiation Dose in Patients With Suspected Urolithiasis. JAMA Intern Med, 2015. 175: 1413.
https://pubmed.ncbi.nlm.nih.gov/26121191/
53. Rodger, F., *et al*. Diagnostic Accuracy of Low and Ultra-Low Dose CT for Identification of Urinary Tract Stones: A Systematic Review. Urol Int, 2018. 100: 375.
https://pubmed.ncbi.nlm.nih.gov/29649823/
54. Xiang, H., *et al*. Systematic review and meta-analysis of the diagnostic accuracy of low-dose computed tomography of the kidneys, ureters and bladder for urolithiasis. J Med Imaging Radiat Oncol, 2017. 61: 582.
https://pubmed.ncbi.nlm.nih.gov/28139077/
55. Saikiran, P. Effectiveness of Low Dose Over Standard dose CT for Detection of Urolithiasis: A Systematic Review. Indian J Forens Med & Toxicol, 2020. 14: 4447.
http://medicopublication.com/index.php/ijfmt/article/view/12341
56. Moore, C.L., *et al*. Imaging in Suspected Renal Colic: Systematic Review of the Literature and Multispecialty Consensus. J Urol, 2019. 202: 475.
https://pubmed.ncbi.nlm.nih.gov/31412438/
57. Poletti, P.A., *et al*. Low-dose versus standard-dose CT protocol in patients with clinically suspected renal colic. AJR Am J Roentgenol, 2007. 188: 927.
https://pubmed.ncbi.nlm.nih.gov/17377025/
58. Zheng, X., *et al*. Dual-energy computed tomography for characterizing urinary calcified calculi and uric acid calculi: A meta-analysis. Eur J Radiol, 2016. 85: 1843.
https://pubmed.ncbi.nlm.nih.gov/27666626/

59. McGrath, T.A., *et al*. Diagnostic accuracy of dual-energy computed tomography (DECT) to differentiate uric acid from non-uric acid calculi: systematic review and meta-analysis. Eur Radiol, 2020. 30: 2791.
https://pubmed.ncbi.nlm.nih.gov/31980881/
60. Mandel, N., *et al*. Conversion of calcium oxalate to calcium phosphate with recurrent stone episodes. J Urol, 2003. 169: 2026.
https://pubmed.ncbi.nlm.nih.gov/12771710/
61. Kourambas, J., *et al*. Role of stone analysis in metabolic evaluation and medical treatment of nephrolithiasis. J Endourol, 2001. 15: 181.
https://pubmed.ncbi.nlm.nih.gov/11325090/
62. Hesse, A., *et al*. Quality control in urinary stone analysis: results of 44 ring trials (1980-2001). Clin Chem Lab Med, 2005. 43: 298.
https://pubmed.ncbi.nlm.nih.gov/15843235/
63. Sutor, D.J., *et al*. Identification standards for human urinary calculus components, using crystallographic methods. Br J Urol, 1968. 40: 22.
https://pubmed.ncbi.nlm.nih.gov/5642759/
64. Abdel-Halim, R.E., *et al*. A review of urinary stone analysis techniques. Saudi Med J, 2006. 27: 1462.
https://pubmed.ncbi.nlm.nih.gov/17013464/
65. Gilad, R., *et al*. Interpreting the results of chemical stone analysis in the era of modern stone analysis techniques. J Nephrol, 2017. 30: 135.
https://pubmed.ncbi.nlm.nih.gov/26956131/
66. Thiruchelvam, N., *et al*. Planning percutaneous nephrolithotomy using multidetector computed tomography urography, multiplanar reconstruction and three-dimensional reformatting. BJU Int, 2005. 95: 1280.
https://pubmed.ncbi.nlm.nih.gov/15892817/
67. Bonkat, G., *et al*., EAU Guidelines on Urological Infections, in EAU Guidelines, Edn. published as the 37th EAU Annual Meeting, Amsterdam, E.A.o.U.G. Office, Editor. 2022, European Association of Urology Guidelines Office: Arnhem, The Netherlands.
68. Somani, B.K., *et al*. Review on diagnosis and management of urolithiasis in pregnancy: an ESUT practical guide for urologists. World J Urol, 2017. 35: 1637.
https://pubmed.ncbi.nlm.nih.gov/28424869/
69. Asrat, T., *et al*. Ultrasonographic detection of ureteral jets in normal pregnancy. Am J Obstet Gynecol, 1998. 178: 1194.
https://pubmed.ncbi.nlm.nih.gov/9662301/
70. Swartz, M.A., *et al*. Admission for nephrolithiasis in pregnancy and risk of adverse birth outcomes. Obstet Gynecol, 2007. 109: 1099.
https://pubmed.ncbi.nlm.nih.gov/17470589/
71. Patel, S.J., *et al*. Imaging the pregnant patient for nonobstetric conditions: algorithms and radiation dose considerations. Radiographics, 2007. 27: 1705.
https://pubmed.ncbi.nlm.nih.gov/18025513/
72. Roy, C., *et al*. Assessment of painful ureterohydronephrosis during pregnancy by MR urography. Eur Radiol, 1996. 6: 334.
https://pubmed.ncbi.nlm.nih.gov/8798002/
73. Juan, Y.S., *et al*. Management of symptomatic urolithiasis during pregnancy. Kaohsiung J Med Sci, 2007. 23: 241.
https://pubmed.ncbi.nlm.nih.gov/17525006/
74. Masselli, G., *et al*. Stone disease in pregnancy: imaging-guided therapy. Insights Imaging, 2014. 5: 691.
https://pubmed.ncbi.nlm.nih.gov/25249333/
75. MHRA, Safety Guidelines for Magnetic Resonance Imaging Equipment in Clinical Use, MHRA, Editor. 2015, MHRA.
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/958486/MRI_guidance_2021-4-03c.pdf
76. ACOG Committee Opinion No. 723: Guidelines for Diagnostic Imaging During Pregnancy and Lactation. Obstet Gynecol, 2017. 130: e210.
https://pubmed.ncbi.nlm.nih.gov/28937575/
77. AIUM Practice parameter for the performance of obstetric ultrasound examinations 2013,
https://onlinelibrary.wiley.com/doi/abs/10.7863/jum.2013.32.6.1083
78. F.D.A. Avoid Fetal “Keepsake” Images, Heartbeat Monitors. 2014. 2018.
https://www.fda.gov/consumers/consumer-updates/avoid-fetal-keepsake-images-heartbeat-monitors

79. Sharp, C., *et al*., Diagnostic Medical Exposures: Advice on Exposure to Ionising Radiation during Pregnancy. 1998, Chilton, Didcot, Oxon, OX11 0RQ.
https://inis.iaea.org/search/search.aspx?orig_q=RN:31046372
80. Kanal, E., *et al*. ACR guidance document for safe MR practices: 2007. AJR Am J Roentgenol, 2007. 188: 1447.
https://pubmed.ncbi.nlm.nih.gov/17515363/
81. White, W.M., *et al*. Predictive value of current imaging modalities for the detection of urolithiasis during pregnancy: a multicenter, longitudinal study. J Urol, 2013. 189: 931.
https://pubmed.ncbi.nlm.nih.gov/23017526/
82. Sternberg, K., *et al*. Pediatric stone disease: an evolving experience. J Urol, 2005. 174: 1711.
https://pubmed.ncbi.nlm.nih.gov/16148688/
83. ICRP. The 2007 Recommendations of the International Commission on Radiological Protection. ICRP publication 103, 2007. 37.
https://www.icrp.org/publication.asp?id=ICRP%20Publication%20103
84. Passerotti, C., *et al*. Ultrasound versus computerized tomography for evaluating urolithiasis. J Urol, 2009. 182: 1829.
https://pubmed.ncbi.nlm.nih.gov/19692054/
85. Tasian, G.E., *et al*. Evaluation and medical management of kidney stones in children. J Urol, 2014. 192: 1329.
https://pubmed.ncbi.nlm.nih.gov/24960469/
86. Palmer, L.S. Pediatric urologic imaging. Urol Clin North Am, 2006. 33: 409.
https://pubmed.ncbi.nlm.nih.gov/16829274/
87. Riccabona, M., *et al*. Imaging recommendations in paediatric uroradiology. Minutes of the ESPR uroradiology task force session on childhood obstructive uropathy, high-grade fetal hydronephrosis, childhood haematuria, and urolithiasis in childhood. ESPR Annual Congress, Edinburgh, UK, June 2008. Pediatr Radiol, 2009. 39: 891.
https://pubmed.ncbi.nlm.nih.gov/19565235/
88. Darge, K., *et al*. [Modern ultrasound technologies and their application in pediatric urinary tract imaging]. Radiologe, 2005. 45: 1101.
https://pubmed.ncbi.nlm.nih.gov/16086170/
89. Pepe, P., *et al*. Functional evaluation of the urinary tract by color-Doppler ultrasonography (CDU) in 100 patients with renal colic. Eur J Radiol, 2005. 53: 131.
https://pubmed.ncbi.nlm.nih.gov/15607864/
90. Oner, S., *et al*. Comparison of spiral CT and US in the evaluation of pediatric urolithiasis. Jbr-btr, 2004. 87: 219.
https://pubmed.ncbi.nlm.nih.gov/15587558/
91. Palmer, J.S., *et al*. Diagnosis of pediatric urolithiasis: role of ultrasound and computerized tomography. J Urol, 2005. 174: 1413.
https://pubmed.ncbi.nlm.nih.gov/16145452/
92. Riccabona, M., *et al*. Conventional imaging in paediatric uroradiology. Eur J Radiol, 2002. 43: 100.
https://pubmed.ncbi.nlm.nih.gov/12127207/
93. Chateil, J.F., *et al*. [Practical measurement of radiation dose in pediatric radiology: use of the dose surface product in digital fluoroscopy and for neonatal chest radiographs]. J Radiol, 2004. 85: 619.
https://pubmed.ncbi.nlm.nih.gov/15205653/
94. Stratton, K.L., *et al*. Implications of ionizing radiation in the pediatric urology patient. J Urol, 2010. 183: 2137.
https://pubmed.ncbi.nlm.nih.gov/20399463/
95. Rob, S., *et al*. Ultra-low-dose, low-dose, and standard-dose CT of the kidney, ureters, and bladder: is there a difference? Results from a systematic review of the literature. Clin Radiol, 2017. 72: 11.
https://pubmed.ncbi.nlm.nih.gov/27810168/
96. Tamm, E.P., *et al*. Evaluation of the patient with flank pain and possible ureteral calculus. Radiology, 2003. 228: 319.
https://pubmed.ncbi.nlm.nih.gov/12819343/
97. Cody, D.D., *et al*. Strategies for formulating appropriate MDCT techniques when imaging the chest, abdomen, and pelvis in pediatric patients. AJR Am J Roentgenol, 2004. 182: 849.
https://pubmed.ncbi.nlm.nih.gov/15039151/
98. Leppert, A., *et al*. Impact of magnetic resonance urography on preoperative diagnostic workup in children affected by hydronephrosis: should IVU be replaced? J Pediatr Surg, 2002. 37: 1441.
https://pubmed.ncbi.nlm.nih.gov/12378450/

99. Pathan, S.A., *et al*. Delivering safe and effective analgesia for management of renal colic in the emergency department: a double-blind, multigroup, randomised controlled trial. Lancet, 2016. 387: 1999.
https://pubmed.ncbi.nlm.nih.gov/26993881/
100. Pathan, S.A., *et al*. A Systematic Review and Meta-analysis Comparing the Efficacy of Nonsteroidal Anti-inflammatory Drugs, Opioids, and Paracetamol in the Treatment of Acute Renal Colic. Eur Urol, 2018. 73: 583.
https://pubmed.ncbi.nlm.nih.gov/29174580/
101. Forouzanfar, M.M., *et al*. Comparison of Intravenous Ibuprofen with Intravenous Ketorolac in Renal Colic Pain Management; A Clinical Trial. Anesth Pain Med, 2019. 9: e86963.
https://pubmed.ncbi.nlm.nih.gov/30881914/
102. Gu, H.-Y., *et al*. Increasing Nonsteroidal Anti-inflammatory Drugs and Reducing Opioids or Paracetamol in the Management of Acute Renal Colic: Based on Three-Stage Study Design of Network Meta-Analysis of Randomized Controlled Trials. Front Pharmacol, 2019. 10: 96.
https://pubmed.ncbi.nlm.nih.gov/30853910/
103. Krum, H., *et al*. Blood pressure and cardiovascular outcomes in patients taking nonsteroidal antiinflammatory drugs. Cardiovasc Ther, 2012. 30: 342.
https://pubmed.ncbi.nlm.nih.gov/21884017/
104. Bhala, N., *et al*. Vascular and upper gastrointestinal effects of non-steroidal anti-inflammatory drugs: meta-analyses of individual participant data from randomised trials. Lancet, 2013. 382: 769.
https://pubmed.ncbi.nlm.nih.gov/23726390/
105. Holdgate, A., *et al*. Nonsteroidal anti-inflammatory drugs (NSAIDs) versus opioids for acute renal colic. Cochrane Database Syst Rev, 2005: CD004137.
https://pubmed.ncbi.nlm.nih.gov/15846699/
106. Abbasi, S., *et al*. Can low-dose of ketamine reduce the need for morphine in renal colic? A double-blind randomized clinical trial. Am J Emerg Med, 2018. 36: 376.
https://pubmed.ncbi.nlm.nih.gov/28821365/
107. Hosseininejad, S.M., *et al*. Comparing the analgesic efficacy of morphine plus ketamine versus morphine plus placebo in patients with acute renal colic: A double-blinded randomized controlled trial. Am J Emerg Med, 2019. 37: 1118.
https://pubmed.ncbi.nlm.nih.gov/30201237/
108. Forouzan, A., *et al*. Comparison of the Analgesic Effect of Intravenous Ketamine versus Intravenous Morphine in Reducing Pain of Renal Colic Patients: Double-Blind Clinical Trial Study. Rev Recent Clin Trials, 2019. 14: 280.
https://pubmed.ncbi.nlm.nih.gov/31284871/
109. Metry, A.A., *et al*. Lornoxicam with Low-Dose Ketamine versus Pethidine to Control Pain of Acute Renal Colic. Pain Res Treat, 2019. 2019: 3976027.
https://pubmed.ncbi.nlm.nih.gov/31001434/
110. Sotoodehnia, M., *et al*. Low-dose intravenous ketamine versus intravenous ketorolac in pain control in patients with acute renal colic in an emergency setting: a double-blind randomized clinical trial. Korean J Pain, 2019. 32: 97.
https://pubmed.ncbi.nlm.nih.gov/31091508/
111. Beltaief, K., *et al*. Acupuncture versus titrated morphine in acute renal colic: a randomized controlled trial. J Pain Res, 2018. 11: 335.
https://pubmed.ncbi.nlm.nih.gov/29483783/
112. Kaynar, M., *et al*. Comparison of the efficacy of diclofenac, acupuncture, and acetaminophen in the treatment of renal colic. Am J Emerg Med, 2015. 33: 749.
https://pubmed.ncbi.nlm.nih.gov/25827597/
113. Holdgate, A., *et al*. Systematic review of the relative efficacy of non-steroidal anti-inflammatory drugs and opioids in the treatment of acute renal colic. BMJ, 2004. 328: 1401.
https://pubmed.ncbi.nlm.nih.gov/15178585/
114. Seitz, C., *et al*. Medical therapy to facilitate the passage of stones: what is the evidence? Eur Urol, 2009. 56: 455.
https://pubmed.ncbi.nlm.nih.gov/19560860/
115. Lee, A., *et al*. Effects of nonsteroidal anti-inflammatory drugs on postoperative renal function in adults with normal renal function. Cochrane Database Syst Rev, 2007: CD002765.
https://pubmed.ncbi.nlm.nih.gov/17443518/
116. Hollingsworth, J.M., *et al*. Alpha blockers for treatment of ureteric stones: systematic review and meta-analysis. BMJ, 2016. 355: i6112.
https://pubmed.ncbi.nlm.nih.gov/27908918/

117. Guercio, S., *et al*. Randomized prospective trial comparing immediate versus delayed ureteroscopy for patients with ureteral calculi and normal renal function who present to the emergency department. J Endourol, 2011. 25: 1137.
https://pubmed.ncbi.nlm.nih.gov/21682597/
118. European Medicines Agency. Metamizole containing medicinal products. European Medicines Agency (EMA), 2019. EMA/191666/2019
https://www.ema.europa.eu/en/medicines/human/referrals/metamizole-containing-medicinal-products
119. Ramsey, S., *et al*. Evidence-based drainage of infected hydronephrosis secondary to ureteric calculi. J Endourol, 2010. 24: 185.
https://pubmed.ncbi.nlm.nih.gov/20063999/
120. Lynch, M.F., *et al*. Percutaneous nephrostomy and ureteric stent insertion for acute renal deobstruction: Consensus based guidance. Brit J Med Surg Urol, 2008. 1: 120.
https://journals.sagepub.com/doi/abs/10.1016/j.bjmsu.2008.09.002
121. Pearle, M.S., *et al*. Optimal method of urgent decompression of the collecting system for obstruction and infection due to ureteral calculi. J Urol, 1998. 160: 1260.
https://pubmed.ncbi.nlm.nih.gov/9751331/
122. Wang, C.J., *et al*. Percutaneous nephrostomy versus ureteroscopic management of sepsis associated with ureteral stone impaction: a randomized controlled trial. Urolithiasis, 2016. 44: 415.
https://pubmed.ncbi.nlm.nih.gov/26662171/
123. Marien, T., *et al*. Antimicrobial resistance patterns in cases of obstructive pyelonephritis secondary to stones. Urology, 2015. 85: 64.
https://pubmed.ncbi.nlm.nih.gov/25530365/
124. Dellabella, M., *et al*. Randomized trial of the efficacy of tamsulosin, nifedipine and phloroglucinol in medical expulsive therapy for distal ureteral calculi. J Urol, 2005. 174: 167.
https://pubmed.ncbi.nlm.nih.gov/15947613/
125. Borghi, L., *et al*. Nifedipine and methylprednisolone in facilitating ureteral stone passage: a randomized, double-blind, placebo-controlled study. J Urol, 1994. 152: 1095.
https://pubmed.ncbi.nlm.nih.gov/8072071/
126. Porpiglia, F., *et al*. Effectiveness of nifedipine and deflazacort in the management of distal ureter stones. Urology, 2000. 56: 579.
https://pubmed.ncbi.nlm.nih.gov/11018608/
127. Dellabella, M., *et al*. Medical-expulsive therapy for distal ureterolithiasis: randomized prospective study on role of corticosteroids used in combination with tamsulosin-simplified treatment regimen and health-related quality of life. Urology, 2005. 66: 712.
https://pubmed.ncbi.nlm.nih.gov/16230122/
128. Yilmaz, E., *et al*. The comparison and efficacy of 3 different alpha1-adrenergic blockers for distal ureteral stones. J Urol, 2005. 173: 2010.
https://pubmed.ncbi.nlm.nih.gov/15879806/
129. Liu, X.J., *et al*. Role of silodosin as medical expulsive therapy in ureteral calculi: a meta-analysis of randomized controlled trials. Urolithiasis, 2017.
https://pubmed.ncbi.nlm.nih.gov/28365782/
130. Hsu, Y.P., *et al*. Silodosin versus tamsulosin for medical expulsive treatment of ureteral stones: A systematic review and meta-analysis. PLoS One, 2018. 13: e0203035.
https://pubmed.ncbi.nlm.nih.gov/30153301/
131. Pickard, R., *et al*. Medical expulsive therapy in adults with ureteric colic: a multicentre, randomised, placebo-controlled trial. Lancet, 2015. 386: 341.
https://pubmed.ncbi.nlm.nih.gov/25998582/
132. Furyk, J.S., *et al*. Distal Ureteric Stones and Tamsulosin: A Double-Blind, Placebo-Controlled, Randomized, Multicenter Trial. Ann Emerg Med, 2016. 67: 86.
https://pubmed.ncbi.nlm.nih.gov/26194935/
133. Sur, R.L., *et al*. Silodosin to facilitate passage of ureteral stones: a multi-institutional, randomized, double-blinded, placebo-controlled trial. Eur Urol, 2015. 67: 959.
https://pubmed.ncbi.nlm.nih.gov/25465978/
134. Turk, C., *et al*. Medical Expulsive Therapy for Ureterolithiasis: The EAU Recommendations in 2016. Eur Urol, 2016.
https://pubmed.ncbi.nlm.nih.gov/27506951/
135. Ye, Z., *et al*. Efficacy and Safety of Tamsulosin in Medical Expulsive Therapy for Distal Ureteral Stones with Renal Colic: A Multicenter, Randomized, Double-blind, Placebo-controlled Trial. Eur Urol, 2017.
https://pubmed.ncbi.nlm.nih.gov/29137830/

136. Bai, Y., *et al*. Tadalafil Facilitates the Distal Ureteral Stone Expulsion: A Meta-Analysis. J Endourol, 2017. 31: 557.
https://pubmed.ncbi.nlm.nih.gov/28384011/
137. Porpiglia, F., *et al*. Corticosteroids and tamsulosin in the medical expulsive therapy for symptomatic distal ureter stones: single drug or association? Eur Urol, 2006. 50: 339.
https://pubmed.ncbi.nlm.nih.gov/16574310/
138. Kachrilas, S., *et al*. The current role of percutaneous chemolysis in the management of urolithiasis: review and results. Urolithiasis, 2013. 41: 323.
https://pubmed.ncbi.nlm.nih.gov/23743991/
139. Bernardo, N.O., *et al*. Chemolysis of urinary calculi. Urol Clin North Am, 2000. 27: 355.
https://pubmed.ncbi.nlm.nih.gov/10778477/
140. Tiselius, H.G., *et al*. Minimally invasive treatment of infection staghorn stones with shock wave lithotripsy and chemolysis. Scand J Urol Nephrol, 1999. 33: 286.
https://pubmed.ncbi.nlm.nih.gov/10572989/
141. Rodman, J.S., *et al*. Dissolution of uric acid calculi. J Urol, 1984. 131: 1039.
https://pubmed.ncbi.nlm.nih.gov/6726897/
142. Becker, G. Uric acid stones. Nephrology, 2007. 12: S21.
https://pubmed.ncbi.nlm.nih.gov/17316272/
143. Elsawy Amr, A., *et al*. Can We Predict the Outcome of Oral Dissolution Therapy for Radiolucent Renal Calculi? A Prospective Study. J Urol, 2019. 201: 350.
https://pubmed.ncbi.nlm.nih.gov/30218763/
144. El-Gamal, O., *et al*. Role of combined use of potassium citrate and tamsulosin in the management of uric acid distal ureteral calculi. Urol Res, 2012. 40: 219.
https://pubmed.ncbi.nlm.nih.gov/21858663/
145. Elbaset, M.A., *et al*. Optimal non-invasive treatment of 1–2.5 cm radiolucent renal stones: oral dissolution therapy, shock wave lithotripsy or combined treatment—a randomized controlled trial. World J Urol, 2020. 38: 207.
https://pubmed.ncbi.nlm.nih.gov/30944968/
146. Musa, A.A. Use of double-J stents prior to extracorporeal shock wave lithotripsy is not beneficial: results of a prospective randomized study. Int Urol Nephrol, 2008. 40: 19.
https://pubmed.ncbi.nlm.nih.gov/17394095/
147. Shen, P., *et al*. Use of ureteral stent in extracorporeal shock wave lithotripsy for upper urinary calculi: a systematic review and meta-analysis. J Urol, 2011. 186: 1328.
https://pubmed.ncbi.nlm.nih.gov/21855945/
148. Wang, H., *et al*. Meta-Analysis of Stenting versus Non-Stenting for the Treatment of Ureteral Stones. PLoS One, 2017. 12: e0167670.
https://pubmed.ncbi.nlm.nih.gov/28068364/
149. Ghoneim, I.A., *et al*. Extracorporeal shock wave lithotripsy in impacted upper ureteral stones: a prospective randomized comparison between stented and non-stented techniques. Urology, 2010. 75: 45.
https://pubmed.ncbi.nlm.nih.gov/19811806/
150. Platonov, M.A., *et al*. Pacemakers, implantable cardioverter/defibrillators, and extracorporeal shockwave lithotripsy: evidence-based guidelines for the modern era. J Endourol, 2008. 22: 243.
https://pubmed.ncbi.nlm.nih.gov/18294028/
151. Li, W.M., *et al*. Clinical predictors of stone fragmentation using slow-rate shock wave lithotripsy. Urol Int, 2007. 79: 124.
https://pubmed.ncbi.nlm.nih.gov/17851280/
152. Yilmaz, E., *et al*. Optimal frequency in extracorporeal shock wave lithotripsy: prospective randomized study. Urology, 2005. 66: 1160.
https://pubmed.ncbi.nlm.nih.gov/16360432/
153. Pace, K.T., *et al*. Shock wave lithotripsy at 60 or 120 shocks per minute: a randomized, double-blind trial. J Urol, 2005. 174: 595.
https://pubmed.ncbi.nlm.nih.gov/16006908/
154. Madbouly, K., *et al*. Slow versus fast shock wave lithotripsy rate for urolithiasis: a prospective randomized study. J Urol, 2005. 173: 127.
https://pubmed.ncbi.nlm.nih.gov/15592053/
155. Semins, M.J., *et al*. The effect of shock wave rate on the outcome of shock wave lithotripsy: a meta-analysis. J Urol, 2008. 179: 194.
https://pubmed.ncbi.nlm.nih.gov/18001796/

156. Li, K., *et al*. Optimal frequency of shock wave lithotripsy in urolithiasis treatment: a systematic review and meta-analysis of randomized controlled trials. J Urol, 2013. 190: 1260.
https://pubmed.ncbi.nlm.nih.gov/23538240/
157. Nguyen, D.P., *et al*. Optimization of Extracorporeal Shock Wave Lithotripsy Delivery Rates Achieves Excellent Outcomes for Ureteral Stones: Results of a Prospective Randomized Trial. J Urol, 2015. 194: 418.
https://pubmed.ncbi.nlm.nih.gov/25661296/
158. Pishchalnikov, Y.A., *et al*. Why stones break better at slow shockwave rates than at fast rates: in vitro study with a research electrohydraulic lithotripter. J Endourol, 2006. 20: 537.
https://pubmed.ncbi.nlm.nih.gov/16903810/
159. Kang, D.H., *et al*. Comparison of High, Intermediate, and Low Frequency Shock Wave Lithotripsy for Urinary Tract Stone Disease: Systematic Review and Network Meta-Analysis. PLoS One, 2016. 11: e0158661.
https://pubmed.ncbi.nlm.nih.gov/27387279/
160. Al-Dessoukey, A.A., *et al*. Ultraslow full-power shock wave lithotripsy versus slow power-ramping shock wave lithotripsy in stones with high attenuation value: A randomized comparative study. Int J Urol, 2020. 27: 165.
https://pubmed.ncbi.nlm.nih.gov/31793084/
161. Connors, B.A., *et al*. Extracorporeal shock wave lithotripsy at 60 shock waves/min reduces renal injury in a porcine model. BJU Int, 2009. 104: 1004.
https://pubmed.ncbi.nlm.nih.gov/19338532/
162. Moon, K.B., *et al*. Optimal shock wave rate for shock wave lithotripsy in urolithiasis treatment: a prospective randomized study. Korean J Urol, 2012. 53: 790.
https://pubmed.ncbi.nlm.nih.gov/23185672/
163. Ng, C.F., *et al*. A prospective, randomized study of the clinical effects of shock wave delivery for unilateral kidney stones: 60 versus 120 shocks per minute. J Urol, 2012. 188: 837.
https://pubmed.ncbi.nlm.nih.gov/22819406/
164. Al-Dessoukey, A.A., *et al*. Ultraslow full-power shock wave lithotripsy protocol in the management of high attenuation value upper ureteric stones: A randomized comparative study. Int J Urol, 2021. 28: 33.
https://pubmed.ncbi.nlm.nih.gov/32985780/
165. Lopez-Acon, J.D., *et al*. Analysis of the Efficacy and Safety of Increasing the Energy Dose Applied Per Session by Increasing the Number of Shock Waves in Extracorporeal Lithotripsy: A Prospective and Comparative Study. J Endourol, 2017. 31: 1289.
https://pubmed.ncbi.nlm.nih.gov/29048206/
166. Connors, B.A., *et al*. Effect of initial shock wave voltage on shock wave lithotripsy-induced lesion size during step-wise voltage ramping. BJU Int, 2009. 103: 104.
https://pubmed.ncbi.nlm.nih.gov/18680494/
167. Handa, R.K., *et al*. Optimising an escalating shockwave amplitude treatment strategy to protect the kidney from injury during shockwave lithotripsy. BJU Int, 2012. 110: E1041.
https://pubmed.ncbi.nlm.nih.gov/22612388/
168. Skuginna, V., *et al*. Does Stepwise Voltage Ramping Protect the Kidney from Injury During Extracorporeal Shockwave Lithotripsy? Results of a Prospective Randomized Trial. Eur Urol, 2016. 69: 267.
https://pubmed.ncbi.nlm.nih.gov/26119561/
169. Maloney, M.E., *et al*. Progressive increase of lithotripter output produces better in-vivo stone comminution. J Endourol, 2006. 20: 603.
https://pubmed.ncbi.nlm.nih.gov/16999607/
170. Demirci, D., *et al*. Comparison of conventional and step-wise shockwave lithotripsy in management of urinary calculi. J Endourol, 2007. 21: 1407.
https://pubmed.ncbi.nlm.nih.gov/18044996/
171. Honey, R.J., *et al*. Shock wave lithotripsy: a randomized, double-blind trial to compare immediate versus delayed voltage escalation. Urology, 2010. 75: 38.
https://pubmed.ncbi.nlm.nih.gov/19896176/
172. Ng, C.F., *et al*. Effect of Stepwise Voltage Escalation on Treatment Outcomes following Extracorporeal Shock Wave Lithotripsy of Renal Calculi: A Prospective Randomized Study. J Urol, 2019. 202: 986.
https://pubmed.ncbi.nlm.nih.gov/31112104/
173. Abdelbary, A.M., *et al*. Value of early second session shock wave lithotripsy in treatment of upper ureteric stones compared to laser ureteroscopy. World J Urol, 2021. 39: 3089.
https://pubmed.ncbi.nlm.nih.gov/33471164/

174. Pishchalnikov, Y.A., *et al*. Air pockets trapped during routine coupling in dry head lithotripsy can significantly decrease the delivery of shock wave energy. J Urol, 2006. 176: 2706.
https://pubmed.ncbi.nlm.nih.gov/17085200/
175. Jain, A., *et al*. Effect of air bubbles in the coupling medium on efficacy of extracorporeal shock wave lithotripsy. Eur Urol, 2007. 51: 1680.
https://pubmed.ncbi.nlm.nih.gov/17112655/
176. Van Besien, J., *et al*. Ultrasonography Is Not Inferior to Fluoroscopy to Guide Extracorporeal Shock Waves during Treatment of Renal and Upper Ureteric Calculi: A Randomized Prospective Study. Biomed Res Int, 2017. 2017: 7802672.
https://pubmed.ncbi.nlm.nih.gov/28589147/
177. Eichel, L., *et al*. Operator experience and adequate anesthesia improve treatment outcome with third-generation lithotripters. J Endourol, 2001. 15: 671.
https://pubmed.ncbi.nlm.nih.gov/11697394/
178. Sorensen, C., *et al*. Comparison of intravenous sedation versus general anesthesia on the efficacy of the Doli 50 lithotriptor. J Urol, 2002. 168: 35.
https://pubmed.ncbi.nlm.nih.gov/12050487/
179. Cleveland, R.O., *et al*. Effect of stone motion on in vitro comminution efficiency of Storz Modulith SLX. J Endourol, 2004. 18: 629.
https://pubmed.ncbi.nlm.nih.gov/15597649/
180. Aboumarzouk, O.M., *et al*. Analgesia for patients undergoing shockwave lithotripsy for urinary stones - a systematic review and meta-analysis. Int Braz J Urol, 2017. 43: 394.
https://pubmed.ncbi.nlm.nih.gov/28338301/
181. Honey, R.J., *et al*. A prospective study examining the incidence of bacteriuria and urinary tract infection after shock wave lithotripsy with targeted antibiotic prophylaxis. J Urol, 2013. 189: 2112.
https://pubmed.ncbi.nlm.nih.gov/23276509/
182. Lu, Y., *et al*. Antibiotic prophylaxis for shock wave lithotripsy in patients with sterile urine before treatment may be unnecessary: a systematic review and meta-analysis. J Urol, 2012. 188: 441.
https://pubmed.ncbi.nlm.nih.gov/22704118/
183. Chen, K., *et al*. The Efficacy and Safety of Tamsulosin Combined with Extracorporeal Shockwave Lithotripsy for Urolithiasis: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. J Endourol, 2015. 29: 1166.
https://pubmed.ncbi.nlm.nih.gov/25915454/
184. Naja, V., *et al*. Tamsulosin facilitates earlier clearance of stone fragments and reduces pain after shockwave lithotripsy for renal calculi: results from an open-label randomized study. Urology, 2008. 72: 1006.
https://pubmed.ncbi.nlm.nih.gov/18799202/
185. Zhu, Y., *et al*. alpha-Blockers to assist stone clearance after extracorporeal shock wave lithotripsy: a meta-analysis. BJU Int, 2010. 106: 256.
https://pubmed.ncbi.nlm.nih.gov/19889063/
186. Zheng, S., *et al*. Tamsulosin as adjunctive treatment after shockwave lithotripsy in patients with upper urinary tract stones: a systematic review and meta-analysis. Scand J Urol Nephrol, 2010. 44: 425.
https://pubmed.ncbi.nlm.nih.gov/21080841/
187. Schuler, T.D., *et al*. Medical expulsive therapy as an adjunct to improve shockwave lithotripsy outcomes: a systematic review and meta-analysis. J Endourol, 2009. 23: 387.
https://pubmed.ncbi.nlm.nih.gov/19245302/
188. Li, M., *et al*. Adjunctive medical therapy with alpha-blocker after extracorporeal shock wave lithotripsy of renal and ureteral stones: a meta-analysis. PLoS One, 2015. 10: e0122497.
https://pubmed.ncbi.nlm.nih.gov/25860144/
189. Skolarikos, A., *et al*. The Efficacy of Medical Expulsive Therapy (MET) in Improving Stone-free Rate and Stone Expulsion Time, After Extracorporeal Shock Wave Lithotripsy (SWL) for Upper Urinary Stones: A Systematic Review and Meta-analysis. Urology, 2015. 86: 1057.
https://pubmed.ncbi.nlm.nih.gov/26383613/
190. De Nunzio, C., *et al*. Tamsulosin or Silodosin Adjuvant Treatment Is Ineffective in Improving Shockwave Lithotripsy Outcome: A Short-Term Follow-Up Randomized, Placebo-Controlled Study. J Endourol, 2016. 30: 817.
https://pubmed.ncbi.nlm.nih.gov/27080916/
191. Aamir Ali, S., *et al*. Comparison of efficacy with & without Tamsulosin as medical adjuvant therapy after Extracorporeal shockwave lithotripsy in renal stone. RMJ, 2018. 43: 471.
https://www.bibliomed.org/?mno=276346

192. Zeng, T., *et al*. Effect of mechanical percussion combined with patient position change on the elimination of upper urinary stones/fragments: a systematic review and meta-analysis. Urolithiasis, 2020. 48: 95.
https://pubmed.ncbi.nlm.nih.gov/31062070/
193. Jing, S., *et al*. Modified Mechanical Percussion for Upper Urinary Tract Stone Fragments After Extracorporeal Shock Wave Lithotripsy: A Prospective Multicenter Randomized Controlled Trial. Urology, 2018. 116: 47.
https://pubmed.ncbi.nlm.nih.gov/29545046/
194. Liu, L.R., *et al*. Percussion, diuresis, and inversion therapy for the passage of lower pole kidney stones following shock wave lithotripsy. Cochrane Database Syst Rev, 2013: Cd008569.
https://pubmed.ncbi.nlm.nih.gov/24318643/
195. Tao, R.Z., *et al*. External physical vibration lithecbole facilitating the expulsion of upper ureteric stones 1.0-2.0 cm after extracorporeal shock wave lithotripsy: a prospective randomized trial. Urolithiasis, 2018.
https://pubmed.ncbi.nlm.nih.gov/30488093/
196. Yuan, C., *et al*. Efficacy and Safety of External Physical Vibration Lithecbole After Extracorporeal Shock Wave Lithotripsy or Retrograde Intrarenal Surgery for Urinary Stone: A Systematic Review and Meta-analysis. J Endourol, 2021. 35: 712.
https://pubmed.ncbi.nlm.nih.gov/32972194/
197. Pearle, M.S., *et al*. Prospective, randomized trial comparing shock wave lithotripsy and ureteroscopy for lower pole caliceal calculi 1 cm or less. J Urol, 2005. 173: 2005.
https://pubmed.ncbi.nlm.nih.gov/15879805/
198. Lingeman, J.E., *et al*. Comparison of results and morbidity of percutaneous nephrostolithotomy and extracorporeal shock wave lithotripsy. J Urol, 1987. 138: 485.
https://pubmed.ncbi.nlm.nih.gov/3625845/
199. Preminger, G.M., *et al*. 2007 Guideline for the management of ureteral calculi. Eur Urol, 2007. 52: 1610.
https://pubmed.ncbi.nlm.nih.gov/18074433/
200. Lingeman, J.E., *et al*. Blood pressure changes following extracorporeal shock wave lithotripsy and other forms of treatment for nephrolithiasis. JAMA, 1990. 263: 1789.
https://pubmed.ncbi.nlm.nih.gov/2313851/
201. Krambeck, A.E., *et al*. Diabetes mellitus and hypertension associated with shock wave lithotripsy of renal and proximal ureteral stones at 19 years of followup. J Urol, 2006. 175: 1742.
https://pubmed.ncbi.nlm.nih.gov/16600747/
202. Eassa, W.A., *et al*. Prospective study of the long-term effects of shock wave lithotripsy on renal function and blood pressure. J Urol, 2008. 179: 964.
https://pubmed.ncbi.nlm.nih.gov/18207167/
203. Yu, C., *et al*. A systematic review and meta-analysis of new onset hypertension after extracorporeal shock wave lithotripsy. Int Urol Nephrol, 2014. 46: 719.
https://pubmed.ncbi.nlm.nih.gov/24162890/
204. Fankhauser, C.D., *et al*. Long-term Adverse Effects of Extracorporeal Shock-wave Lithotripsy for Nephrolithiasis and Ureterolithiasis: A Systematic Review. Urology, 2015. 85: 991.
https://pubmed.ncbi.nlm.nih.gov/25917723/
205. Fankhauser, C.D., *et al*. Prevalence of hypertension and diabetes after exposure to extracorporeal shock-wave lithotripsy in patients with renal calculi: a retrospective non-randomized data analysis. Int Urol Nephrol, 2018. 50: 1227.
https://pubmed.ncbi.nlm.nih.gov/29785660/
206. Chen, C.S., *et al*. Subcapsular hematoma of spleen--a complication following extracorporeal shock wave lithotripsy for ureteral calculus. Changgeng Yi Xue Za Zhi, 1992. 15: 215.
https://pubmed.ncbi.nlm.nih.gov/1295657/
207. Skolarikos, A., *et al*. Extracorporeal shock wave lithotripsy 25 years later: complications and their prevention. Eur Urol, 2006. 50: 981.
https://pubmed.ncbi.nlm.nih.gov/16481097/
208. Osman, M.M., *et al*. 5-year-follow-up of patients with clinically insignificant residual fragments after extracorporeal shockwave lithotripsy. Eur Urol, 2005. 47: 860.
https://pubmed.ncbi.nlm.nih.gov/15925084/
209. Tan, Y.M., *et al*. Clinical experience and results of ESWL treatment for 3,093 urinary calculi with the Storz Modulith SL 20 lithotripter at the Singapore general hospital. Scand J Urol Nephrol, 2002. 36: 363.
https://pubmed.ncbi.nlm.nih.gov/12487741/

210. Muller-Mattheis, V.G., *et al*. Bacteremia during extracorporeal shock wave lithotripsy of renal calculi. J Urol, 1991. 146: 733.
https://pubmed.ncbi.nlm.nih.gov/1875482/
211. Dhar, N.B., *et al*. A multivariate analysis of risk factors associated with subcapsular hematoma formation following electromagnetic shock wave lithotripsy. J Urol, 2004. 172: 2271.
https://pubmed.ncbi.nlm.nih.gov/15538247/
212. Zanetti, G., *et al*. Cardiac dysrhythmias induced by extracorporeal shockwave lithotripsy. J Endourol, 1999. 13: 409.
https://pubmed.ncbi.nlm.nih.gov/10479005/
213. Rodrigues Netto, N., Jr., *et al*. Small-bowel perforation after shockwave lithotripsy. J Endourol, 2003. 17: 719.
https://pubmed.ncbi.nlm.nih.gov/14642028/
214. Holmberg, G., *et al*. Perforation of the bowel during SWL in prone position. J Endourol, 1997. 11: 313.
https://pubmed.ncbi.nlm.nih.gov/9355944/
215. Maker, V., *et al*. Gastrointestinal injury secondary to extracorporeal shock wave lithotripsy: a review of the literature since its inception. J Am Coll Surg, 2004. 198: 128.
https://pubmed.ncbi.nlm.nih.gov/14698320/
216. Kim, T.B., *et al*. Life-threatening complication after extracorporeal shock wave lithotripsy for a renal stone: a hepatic subcapsular hematoma. Korean J Urol, 2010. 51: 212.
https://pubmed.ncbi.nlm.nih.gov/20414400/
217. Ng, C.F., *et al*. Hepatic haematoma after shockwave lithotripsy for renal stones. Urol Res, 2012. 40: 785.
https://pubmed.ncbi.nlm.nih.gov/22782117/
218. Ather, M.H., *et al*. Does ureteral stenting prior to shock wave lithotripsy influence the need for intervention in steinstrasse and related complications? Urol Int, 2009. 83: 222.
https://pubmed.ncbi.nlm.nih.gov/19752621/
219. Madbouly, K., *et al*. Risk factors for the formation of a steinstrasse after extracorporeal shock wave lithotripsy: a statistical model. J Urol, 2002. 167: 1239.
https://pubmed.ncbi.nlm.nih.gov/11832705/
220. Sayed, M.A., *et al*. Steinstrasse after extracorporeal shockwave lithotripsy: aetiology, prevention and management. BJU Int, 2001. 88: 675.
https://pubmed.ncbi.nlm.nih.gov/11890235/
221. Wendt-Nordahl, G., *et al*. Do new generation flexible ureterorenoscopes offer a higher treatment success than their predecessors? Urol Res, 2011. 39: 185.
https://pubmed.ncbi.nlm.nih.gov/21052986/
222. Wang, Q., *et al*. Rigid ureteroscopic lithotripsy versus percutaneous nephrolithotomy for large proximal ureteral stones: A meta-analysis. PLoS One, 2017. 12: e0171478.
https://pubmed.ncbi.nlm.nih.gov/28182718/
223. Wang, Y., *et al*. Comparison of the efficacy and safety of URSL, RPLU, and MPCNL for treatment of large upper impacted ureteral stones: a randomized controlled trial. BMC Urol, 2017. 17: 50.
https://pubmed.ncbi.nlm.nih.gov/28662708/
224. Sun, X., *et al*. Treatment of large impacted proximal ureteral stones: randomized comparison of percutaneous antegrade ureterolithotripsy versus retrograde ureterolithotripsy. J Endourol, 2008. 22: 913.
https://pubmed.ncbi.nlm.nih.gov/18429682/
225. el-Nahas, A.R., *et al*. Percutaneous treatment of large upper tract stones after urinary diversion. Urology, 2006. 68: 500.
https://pubmed.ncbi.nlm.nih.gov/16979745/
226. Moufid, K., *et al*. Large impacted upper ureteral calculi: A comparative study between retrograde ureterolithotripsy and percutaneous antegrade ureterolithotripsy in the modified lateral position. Urol Ann, 2013. 5: 140.
https://pubmed.ncbi.nlm.nih.gov/24049373/
227. El-Assmy, A., *et al*. Extracorporeal shock wave lithotripsy of upper urinary tract calculi in patients with cystectomy and urinary diversion. Urology, 2005. 66: 510.
https://pubmed.ncbi.nlm.nih.gov/16140067/
228. Deng, T., *et al*. Systematic review and cumulative analysis of the managements for proximal impacted ureteral stones. World J Urol, 2019. 37: 1687.
https://pubmed.ncbi.nlm.nih.gov/30430253/
229. Binbay, M., *et al*. Is there a difference in outcomes between digital and fiberoptic flexible ureterorenoscopy procedures? J Endourol, 2010. 24: 1929.
https://pubmed.ncbi.nlm.nih.gov/21043835/

230. Geraghty, R., *et al*. Evidence for Ureterorenoscopy and Laser Fragmentation (URSL) for Large Renal Stones in the Modern Era. Curr Urol Rep, 2015. 16: 54.
https://pubmed.ncbi.nlm.nih.gov/26077357/
231. Auge, B.K., *et al*. Ureteroscopic management of lower-pole renal calculi: technique of calculus displacement. J Endourol, 2001. 15: 835.
https://pubmed.ncbi.nlm.nih.gov/11724125/
232. Luo, Z., *et al*. Comparison of retrograde intrarenal surgery under regional versus general anaesthesia: A systematic review and meta-analysis. Int J Surg, 2020. 82: 36.
https://pubmed.ncbi.nlm.nih.gov/32858209/
233. Schembri, M., *et al*. Outcomes of loco-regional anaesthesia in ureteroscopy for stone disease: a systematic review. Curr Opin Urol, 2020. 30: 726.
https://pubmed.ncbi.nlm.nih.gov/32657841/
234. Wu, T., *et al*. Ureteroscopic Lithotripsy versus Laparoscopic Ureterolithotomy or Percutaneous Nephrolithotomy in the Management of Large Proximal Ureteral Stones: A Systematic Review and Meta-Analysis. Urol Int, 2017. 99: 308.
https://pubmed.ncbi.nlm.nih.gov/28586770/
235. Agrawal, S., *et al*. Initial experience with slimmest single-use flexible ureteroscope Uscope PU3033A (PUSEN™) in retrograde intrarenal surgery and its comparison with Uscope PU3022a: a single-center prospective study. World J Urol, 2021. 39: 3957.
https://pubmed.ncbi.nlm.nih.gov/33970313/
236. Van Compernolle, D., *et al*. Reusable, Single-Use, or Both: A Cost Efficiency Analysis of Flexible Ureterorenoscopes After 983 Cases. J Endourol, 2021. 35: 1454.
https://pubmed.ncbi.nlm.nih.gov/33775101/
237. Dragos, L.B., *et al*. Characteristics of current digital single-use flexible ureteroscopes versus their reusable counterparts: an in-vitro comparative analysis. Transl Androl Urol, 2019. 8: S359.
https://pubmed.ncbi.nlm.nih.gov/31656742/
238. Dickstein, R.J., *et al*. Is a safety wire necessary during routine flexible ureteroscopy? J Endourol, 2010. 24: 1589.
https://pubmed.ncbi.nlm.nih.gov/20836719/
239. Eandi, J.A., *et al*. Evaluation of the impact and need for use of a safety guidewire during ureteroscopy. J Endourol, 2008. 22: 1653.
https://pubmed.ncbi.nlm.nih.gov/18721045/
240. Ulvik, O., *et al*. Ureteroscopy with and without safety guide wire: should the safety wire still be mandatory? J Endourol, 2013. 27: 1197.
https://pubmed.ncbi.nlm.nih.gov/23795760/
241. Ambani, S.N., *et al*. Ureteral stents for impassable ureteroscopy. J Endourol, 2013. 27: 549.
https://pubmed.ncbi.nlm.nih.gov/23066997/
242. Pace, K.T., *et al*. Same Session Bilateral Ureteroscopy for Multiple Stones: Results from the CROES URS Global Study. J Urol, 2017. 198: 130.
https://pubmed.ncbi.nlm.nih.gov/28163031/
243. Ge, H., *et al*. Bilateral Same-Session Ureteroscopy for Treatment of Ureteral Calculi: A Systematic Review and Meta-Analysis. J Endourol, 2016. 30: 1169.
https://pubmed.ncbi.nlm.nih.gov/27626367/
244. Karim, S.S., *et al*. Role of pelvicalyceal anatomy in the outcomes of retrograde intrarenal surgery (RIRS) for lower pole stones: outcomes with a systematic review of literature. Urolithiasis, 2020. 48: 263.
https://pubmed.ncbi.nlm.nih.gov/31372691/
245. Lane, J., *et al*. Correlation of Operative Time with Outcomes of Ureteroscopy and Stone Treatment: a Systematic Review of Literature. Current Urol Rep, 2020. 21: 17.
https://pubmed.ncbi.nlm.nih.gov/32211985/
246. Stern, J.M., *et al*. Safety and efficacy of ureteral access sheaths. J Endourol, 2007. 21: 119.
https://pubmed.ncbi.nlm.nih.gov/17338606/
247. L'Esperance J, O., *et al*. Effect of ureteral access sheath on stone-free rates in patients undergoing ureteroscopic management of renal calculi. Urology, 2005. 66: 252.
https://pubmed.ncbi.nlm.nih.gov/16040093/
248. Traxer, O., *et al*. Prospective evaluation and classification of ureteral wall injuries resulting from insertion of a ureteral access sheath during retrograde intrarenal surgery. J Urol, 2013. 189: 580.
https://pubmed.ncbi.nlm.nih.gov/22982421/
249. Aboumarzouk, O.M., *et al*. Flexible ureteroscopy and laser lithotripsy for stones >2 cm: a systematic review and meta-analysis. J Endourol, 2012. 26: 1257.
https://pubmed.ncbi.nlm.nih.gov/22642568/

250. Traxer, O., *et al*. Differences in renal stone treatment and outcomes for patients treated either with or without the support of a ureteral access sheath: The Clinical Research Office of the Endourological Society Ureteroscopy Global Study. World J Urol, 2015. 33: 2137. https://pubmed.ncbi.nlm.nih.gov/25971204/
251. Stern, K.L., *et al*. A Prospective Study Analyzing the Association Between High-grade Ureteral Access Sheath Injuries and the Formation of Ureteral Strictures. Urology, 2019. 128: 38. https://pubmed.ncbi.nlm.nih.gov/30878681/
252. Lima, A., *et al*. Impact of ureteral access sheath on renal stone treatment: prospective comparative non-randomised outcomes over a 7-year period. World J Urol, 2020. 38: 1329. https://pubmed.ncbi.nlm.nih.gov/31342247/
253. Santiago, J.E., *et al*. To Dust or Not To Dust: a Systematic Review of Ureteroscopic Laser Lithotripsy Techniques. Curr Urol Rep, 2017. 18: 32. https://pubmed.ncbi.nlm.nih.gov/28271355/
254. Bach, T., *et al*. Working tools in flexible ureterorenoscopy--influence on flow and deflection: what does matter? J Endourol, 2008. 22: 1639. https://pubmed.ncbi.nlm.nih.gov/18620506/
255. Leijte, J.A., *et al*. Holmium laser lithotripsy for ureteral calculi: predictive factors for complications and success. J Endourol, 2008. 22: 257. https://pubmed.ncbi.nlm.nih.gov/18294030/
256. Pierre, S., *et al*. Holmium laser for stone management. World J Urol, 2007. 25: 235. https://pubmed.ncbi.nlm.nih.gov/17340157/
257. Ventimiglia, E., *et al*. High- and Low-Power Laser Lithotripsy Achieves Similar Results: A Systematic Review and Meta-Analysis of Available Clinical Series. J Endourol, 2021. 35: 1146. https://pubmed.ncbi.nlm.nih.gov/33677987/
258. Garg, S., *et al*. Ureteroscopic laser lithotripsy versus ballistic lithotripsy for treatment of ureteric stones: a prospective comparative study. Urol Int, 2009. 82: 341. https://pubmed.ncbi.nlm.nih.gov/19440025/
259. Binbay, M., *et al*. Evaluation of pneumatic versus holmium:YAG laser lithotripsy for impacted ureteral stones. Int Urol Nephrol, 2011. 43: 989. https://pubmed.ncbi.nlm.nih.gov/21479563/
260. Ahmed, M., *et al*. Systematic evaluation of ureteral occlusion devices: insertion, deployment, stone migration, and extraction. Urology, 2009. 73: 976. https://pubmed.ncbi.nlm.nih.gov/19394493/
261. John, T.T., *et al*. Adjunctive tamsulosin improves stone free rate after ureteroscopic lithotripsy of large renal and ureteric calculi: a prospective randomized study. Urology, 2010. 75: 1040. https://pubmed.ncbi.nlm.nih.gov/19819530/
262. Martov, A.G., *et al*. Clinical Comparison of Super Pulse Thulium Fiber Laser and High-Power Holmium Laser for Ureteral Stone Management. J Endourol, 2021. 35: 795. https://pubmed.ncbi.nlm.nih.gov/33238763/
263. Kronenberg, P., *et al*. Outcomes of thulium fibre laser for treatment of urinary tract stones: results of a systematic review. Curr Opin Urol, 2021. 31: 80. https://pubmed.ncbi.nlm.nih.gov/33470684/
264. Assimos, D., *et al*. Preoperative JJ stent placement in ureteric and renal stone treatment: results from the Clinical Research Office of Endourological Society (CROES) ureteroscopy (URS) Global Study. BJU Int, 2016. 117: 648. https://pubmed.ncbi.nlm.nih.gov/26237735/
265. Jessen, J.P., *et al*. International Collaboration in Endourology: Multicenter Evaluation of Prestenting for Ureterorenoscopy. J Endourol, 2016. 30: 268. https://pubmed.ncbi.nlm.nih.gov/26582170/
266. Song, T., *et al*. Meta-analysis of postoperatively stenting or not in patients underwent ureteroscopic lithotripsy. Urol Res, 2012. 40: 67. https://pubmed.ncbi.nlm.nih.gov/21573923/
267. Haleblian, G., *et al*. Ureteral stenting and urinary stone management: a systematic review. J Urol, 2008. 179: 424. https://pubmed.ncbi.nlm.nih.gov/18076928/
268. Nabi, G., *et al*. Outcomes of stenting after uncomplicated ureteroscopy: systematic review and meta-analysis. BMJ, 2007. 334: 572. https://pubmed.ncbi.nlm.nih.gov/17311851/

269. Seklehner, S., *et al*. A cost analysis of stenting in uncomplicated semirigid ureteroscopic stone removal. Int Urol Nephrol, 2017. 49: 753.
https://pubmed.ncbi.nlm.nih.gov/28197765/
270. Moon, T.D. Ureteral stenting--an obsolete procedure? J Urol, 2002. 167: 1984.
https://pubmed.ncbi.nlm.nih.gov/11956423/
271. Wang, C.J., *et al*. Effects of specific alpha-1A/1D blocker on lower urinary tract symptoms due to double-J stent: a prospectively randomized study. Urol Res, 2009. 37: 147.
https://pubmed.ncbi.nlm.nih.gov/19277623/
272. Lamb, A.D., *et al*. Meta-analysis showing the beneficial effect of alpha-blockers on ureteric stent discomfort. BJU Int, 2011. 108: 1894.
https://pubmed.ncbi.nlm.nih.gov/21453351/
273. Kim, J.K., *et al*. Silodosin for Prevention of Ureteral Injuries Resulting from Insertion of a Ureteral Access Sheath: A Randomized Controlled Trial. Eur Urol Focus, 2021.
https://pubmed.ncbi.nlm.nih.gov/33741297/
274. Geavlete, P., *et al*. Complications of 2735 retrograde semirigid ureteroscopy procedures: a single-center experience. J Endourol, 2006. 20: 179.
https://pubmed.ncbi.nlm.nih.gov/16548724/
275. Perez Castro, E., *et al*. Differences in ureteroscopic stone treatment and outcomes for distal, mid-, proximal, or multiple ureteral locations: the Clinical Research Office of the Endourological Society ureteroscopy global study. Eur Urol, 2014. 66: 102.
https://pubmed.ncbi.nlm.nih.gov/24507782/
276. Bhojani, N., *et al*. Risk Factors for Urosepsis After Ureteroscopy for Stone Disease: A Systematic Review with Meta-Analysis. J Endourol, 2021. 35: 991.
https://pubmed.ncbi.nlm.nih.gov/33544019/
277. De Coninck, V., *et al*. Complications of ureteroscopy: a complete overview. World J Urol, 2020. 38: 2147.
https://pubmed.ncbi.nlm.nih.gov/31748953/
278. Bhanot, R., *et al*. Predictors and Strategies to Avoid Mortality Following Ureteroscopy for Stone Disease: A Systematic Review from European Association of Urologists Sections of Urolithiasis (EULIS) and Uro-technology (ESUT). Eur Urol Focus, 2021.
https://pubmed.ncbi.nlm.nih.gov/33674255/
279. Chugh, S., *et al*. Predictors of Urinary Infections and Urosepsis After Ureteroscopy for Stone Disease: a Systematic Review from EAU Section of Urolithiasis (EULIS). Curr Urol Rep, 2020. 21: 16.
https://pubmed.ncbi.nlm.nih.gov/32211969/
280. Tokas, T., *et al*. Role of Intrarenal Pressure in Modern Day Endourology (Mini-PCNL and Flexible URS): a Systematic Review of Literature. Curr Urol Rep, 2021. 22: 52.
https://pubmed.ncbi.nlm.nih.gov/34622341/
281. Zeng, G., *et al*. Mini Percutaneous Nephrolithotomy Is a Noninferior Modality to Standard Percutaneous Nephrolithotomy for the Management of 20–40mm Renal Calculi: A Multicenter Randomized Controlled Trial. Eur Urol, 2021. 79: 114.
https://pubmed.ncbi.nlm.nih.gov/32994063/
282. Ruhayel, Y., *et al*. Tract Sizes in Miniaturized Percutaneous Nephrolithotomy: A Systematic Review from the European Association of Urology Urolithiasis Guidelines Panel. Eur Urol, 2017. 72: 220.
https://pubmed.ncbi.nlm.nih.gov/28237786/
283. Tikkinen, K.A.O., *et al*., EAU Guidelines on Thromboprophylaxis in Urological Surgery, in EAU Guidelines, Edn. published as the 32nd EAU Annual Meeting, London, 2017, Editor, European Association of Urology Guidelines Office: Arnhem, The Netherlands.
https://uroweb.org/guideline/thromboprophylaxis/?type=archive
284. Ganesamoni, R., *et al*. Prospective randomized controlled trial comparing laser lithotripsy with pneumatic lithotripsy in miniperc for renal calculi. J Endourol, 2013. 27: 1444.
https://pubmed.ncbi.nlm.nih.gov/24251428/
285. Mak, D.K., *et al*. What is better in percutaneous nephrolithotomy - Prone or supine? A systematic review. Arab J Urol, 2016. 14: 101.
https://pubmed.ncbi.nlm.nih.gov/27489736/
286. Li, J., *et al*. Supine versus prone position for percutaneous nephrolithotripsy: A meta-analysis of randomized controlled trials. Int J Surg, 2019. 66: 62.
https://pubmed.ncbi.nlm.nih.gov/31034987/
287. Cracco, C.M., *et al*. Endoscopic combined intrarenal surgery (ECIRS) - Tips and tricks to improve outcomes: A systematic review. Turk J Urol, 2020. 46: S46.
https://pubmed.ncbi.nlm.nih.gov/32877638/

288. Corrales, M., *et al*. Ultrasound or Fluoroscopy for Percutaneous Nephrolithotomy Access, Is There Really a Difference? A Review of Literature. J Endourol, 2021. 35: 241.
https://pubmed.ncbi.nlm.nih.gov/32762266/
289. Zhu, W., *et al*. A prospective and randomised trial comparing fluoroscopic, total ultrasonographic, and combined guidance for renal access in mini-percutaneous nephrolithotomy. BJU Int, 2017. 119: 612.
https://pubmed.ncbi.nlm.nih.gov/27862806/
290. El-Shaer, W., *et al*. Complete Ultrasound-guided Percutaneous Nephrolithotomy in Prone and Supine Positions: A Randomized Controlled Study. Urology, 2019. 128: 31.
https://pubmed.ncbi.nlm.nih.gov/30902696/
291. Isac, W., *et al*. Endoscopic-guided versus fluoroscopic-guided renal access for percutaneous nephrolithotomy: a comparative analysis. Urology, 2013. 81: 251.
https://pubmed.ncbi.nlm.nih.gov/23374772/
292. Falahatkar, S., *et al*. Complete supine PCNL: ultrasound vs. fluoroscopic guided: a randomized clinical trial. Int Braz J Urol, 2016. 42: 710.
https://pubmed.ncbi.nlm.nih.gov/27564281/
293. Srivastava, A., *et al*. A prospective randomized study comparing the four tract dilation methods of percutaneous nephrolithotomy. World J Urol, 2017. 35: 803.
https://pubmed.ncbi.nlm.nih.gov/27614706/
294. Armas-Phan, M., *et al*. Ultrasound guidance can be used safely for renal tract dilatation during percutaneous nephrolithotomy. BJU Int, 2020. 125: 284.
https://pubmed.ncbi.nlm.nih.gov/30811835/
295. Tzelves, L., *et al*. Suction Use During Endourological Procedures. Curr Urol Rep, 2020. 21: 46.
https://pubmed.ncbi.nlm.nih.gov/32915324/
296. Lu, Y., *et al*. Randomized prospective trial of tubeless versus conventional minimally invasive percutaneous nephrolithotomy. World J Urol, 2013. 31: 1303.
https://pubmed.ncbi.nlm.nih.gov/22903789/
297. Cormio, L., *et al*. Exit strategies following percutaneous nephrolithotomy (PCNL): a comparison of surgical outcomes in the Clinical Research Office of the Endourological Society (CROES) PCNL Global Study. World J Urol, 2013. 31: 1239.
https://pubmed.ncbi.nlm.nih.gov/22752586/
298. Lee, J.Y., *et al*. Intraoperative and postoperative feasibility and safety of total tubeless, tubeless, small-bore tube, and standard percutaneous nephrolithotomy: a systematic review and network meta-analysis of 16 randomized controlled trials. BMC Urol, 2017. 17: 48.
https://pubmed.ncbi.nlm.nih.gov/28655317/
299. Garofalo, M., *et al*. Tubeless procedure reduces hospitalization and pain after percutaneous nephrolithotomy: results of a multivariable analysis. Urolithiasis, 2013. 41: 347.
https://pubmed.ncbi.nlm.nih.gov/23632910/
300. Seitz, C., *et al*. Incidence, prevention, and management of complications following percutaneous nephrolitholapaxy. Eur Urol, 2012. 61: 146.
https://pubmed.ncbi.nlm.nih.gov/21978422/
301. Yu, J., *et al*. Antibiotic prophylaxis in perioperative period of percutaneous nephrolithotomy: a systematic review and meta-analysis of comparative studies. World J Urol, 2020. 38: 1685.
https://pubmed.ncbi.nlm.nih.gov/31562533/
302. Yoshida, S., *et al*. The significance of intraoperative renal pelvic urine and stone cultures for patients at a high risk of post-ureteroscopy systemic inflammatory response syndrome. Urolithiasis, 2019. 47: 533.
https://pubmed.ncbi.nlm.nih.gov/30758524/
303. Wu, C., *et al*. Comparison of renal pelvic pressure and postoperative fever incidence between standard- and mini-tract percutaneous nephrolithotomy. Kaohsiung J Med Sci, 2017. 33: 36.
https://pubmed.ncbi.nlm.nih.gov/28088272/
304. Mariappan, P., *et al*. Stone and pelvic urine culture and sensitivity are better than bladder urine as predictors of urosepsis following percutaneous nephrolithotomy: a prospective clinical study. J Urol, 2005. 173: 1610.
https://pubmed.ncbi.nlm.nih.gov/15821509/
305. Lo, C.W., *et al*. Effectiveness of Prophylactic Antibiotics against Post-Ureteroscopic Lithotripsy Infections: Systematic Review and Meta-Analysis. Surg Infect (Larchmt), 2015. 16: 415.
https://pubmed.ncbi.nlm.nih.gov/26207401/

306. Gravas, S., *et al*. Postoperative infection rates in low risk patients undergoing percutaneous nephrolithotomy with and without antibiotic prophylaxis: a matched case control study. J Urol, 2012. 188: 843.
https://pubmed.ncbi.nlm.nih.gov/22819398/
307. Chew, B.H., *et al*. A Single Dose of Intraoperative Antibiotics Is Sufficient to Prevent Urinary Tract Infection During Ureteroscopy. J Endourol, 2016. 30: 63.
https://pubmed.ncbi.nlm.nih.gov/26413885/
308. Klingler, H.C., *et al*. Stone treatment and coagulopathy. Eur Urol, 2003. 43: 75.
https://pubmed.ncbi.nlm.nih.gov/12507547/
309. Kefer, J.C., *et al*. Safety and efficacy of percutaneous nephrostolithotomy in patients on anticoagulant therapy. J Urol, 2009. 181: 144.
https://pubmed.ncbi.nlm.nih.gov/19012931/
310. Baron, T.H., *et al*. Management of antithrombotic therapy in patients undergoing invasive procedures. N Engl J Med, 2013. 368: 2113.
https://pubmed.ncbi.nlm.nih.gov/23718166/
311. Naspro, R., *et al*. Antiplatelet therapy in patients with coronary stent undergoing urologic surgery: is it still no man's land? Eur Urol, 2013. 64: 101.
https://pubmed.ncbi.nlm.nih.gov/23428067/
312. Eberli, D., *et al*. Urological surgery and antiplatelet drugs after cardiac and cerebrovascular accidents. J Urol, 2010. 183: 2128.
https://pubmed.ncbi.nlm.nih.gov/20399452/
313. Razvi, H., *et al*. Risk factors for perinephric hematoma formation after shockwave lithotripsy: a matched case-control analysis. J Endourol, 2012. 26: 1478.
https://pubmed.ncbi.nlm.nih.gov/22712655/
314. Rassweiler, J.J., *et al*. Treatment of renal stones by extracorporeal shockwave lithotripsy: an update. Eur Urol, 2001. 39: 187.
https://pubmed.ncbi.nlm.nih.gov/11223679/
315. Fischer, C., *et al*. [Extracorporeal shock-wave lithotripsy induced ultrastructural changes to the renal parenchyma under aspirin use. Electron microscopic findings in the rat kidney]. Urologe A, 2007. 46: 150.
https://pubmed.ncbi.nlm.nih.gov/17221245/
316. Becopoulos, T., *et al*. Extracorporeal lithotripsy in patients with hemophilia. Eur Urol, 1988. 14: 343.
https://pubmed.ncbi.nlm.nih.gov/3169076/
317. Ishikawa, J., *et al*. Extracorporeal shock wave lithotripsy in von Willebrand's disease. Int J Urol, 1996. 3: 58.
https://pubmed.ncbi.nlm.nih.gov/8646601/
318. Zanetti, G., *et al*. Cardiac dysrhythmiastreated with antithrombotic agents. J Endourol, 2001. 15: 237.
https://pubmed.ncbi.nlm.nih.gov/11339387/
319. Schnabel, M.J., *et al*. Incidence and risk factors of renal hematoma: a prospective study of 1,300 SWL treatments. Urolithiasis, 2014. 42: 247.
https://pubmed.ncbi.nlm.nih.gov/24419328/
320. Schnabel, M.J., *et al*. Antiplatelet and anticoagulative medication during shockwave lithotripsy. J Endourol, 2014. 28: 1034.
https://pubmed.ncbi.nlm.nih.gov/24851726/
321. Aboumarzouk, O.M., *et al*. Flexible ureteroscopy and holmium:YAG laser lithotripsy for stone disease in patients with bleeding diathesis: a systematic review of the literature. Int Braz J Urol, 2012. 38: 298.
https://pubmed.ncbi.nlm.nih.gov/22765861/
322. Elkoushy, M.A., *et al*. Ureteroscopy in patients with coagulopathies is associated with lower stone-free rate and increased risk of clinically significant hematuria. Int Braz J Urol, 2012. 38: 195.
https://pubmed.ncbi.nlm.nih.gov/22555043/
323. Sharaf, A., *et al*. Ureteroscopy in Patients with Bleeding Diatheses, Anticoagulated, and on Anti-Platelet Agents: A Systematic Review and Meta-Analysis of the Literature. J Endourol, 2017. 31: 1217.
https://pubmed.ncbi.nlm.nih.gov/29048211/
324. Sahin, C., *et al*. Transient cessation of antiplatelet medication before percutaneous stone surgery: does it have any safety concern on bleeding related problems? Urolithiasis, 2017. 45: 371.
https://pubmed.ncbi.nlm.nih.gov/27677484/
325. Kuo, R.L., *et al*. Use of ureteroscopy and holmium:YAG laser in patients with bleeding diatheses. Urology, 1998. 52: 609.
https://pubmed.ncbi.nlm.nih.gov/9763079/

326. Altay, B., *et al*. A review study to evaluate holmium:YAG laser lithotripsy with flexible ureteroscopy in patients on ongoing oral anticoagulant therapy. Lasers Med Sci, 2017. 32: 1615.
https://pubmed.ncbi.nlm.nih.gov/28733910/
327. Gupta, A.D., *et al*. Coronary stent management in elective genitourinary surgery. BJU Int, 2012. 110: 480.
https://pubmed.ncbi.nlm.nih.gov/22192977/
328. Delakas, D., *et al*. Independent predictors of failure of shockwave lithotripsy for ureteral stones employing a second-generation lithotripter. J Endourol, 2003. 17: 201.
https://pubmed.ncbi.nlm.nih.gov/12816580/
329. Lee, J.Y., *et al*. Stone heterogeneity index as the standard deviation of Hounsfield units: A novel predictor for shock-wave lithotripsy outcomes in ureter calculi. Sci Rep, 2016. 6: 23988.
https://pubmed.ncbi.nlm.nih.gov/27035621/
330. Ohmori, K., *et al*. Effects of shock waves on the mouse fetus. J Urol, 1994. 151: 255.
https://pubmed.ncbi.nlm.nih.gov/8254823/
331. Streem, S.B., *et al*. Extracorporeal shock wave lithotripsy in patients with bleeding diatheses. J Urol, 1990. 144: 1347.
https://pubmed.ncbi.nlm.nih.gov/2231922/
332. Carey, S.W., *et al*. Extracorporeal shock wave lithotripsy for patients with calcified ipsilateral renal arterial or abdominal aortic aneurysms. J Urol, 1992. 148: 18.
https://pubmed.ncbi.nlm.nih.gov/1613866/
333. Reeves, T., *et al*. Role of Endourological Procedures (PCNL and URS) on Renal Function: a Systematic Review. Curr Urol Rep, 2020. 21: 21.
https://pubmed.ncbi.nlm.nih.gov/32318942/
334. Skolarikos, A., *et al*. The role for active monitoring in urinary stones: a systematic review. J Endourol, 2010. 24: 923.
https://pubmed.ncbi.nlm.nih.gov/20482232/
335. Yallappa, S., *et al*. Natural History of Conservatively Managed Ureteral Stones: Analysis of 6600 Patients. J Endourol, 2018. 32: 371.
https://pubmed.ncbi.nlm.nih.gov/29482379/
336. Xu, B., *et al*. Meta-analysis of the efficacy of sexual intercourse for distal ureteric stones. J Int Med Res, 2019. 47: 497.
https://pubmed.ncbi.nlm.nih.gov/30621491/
337. Skolarikos, A., *et al*. Indications, prediction of success and methods to improve outcome of shock wave lithotripsy of renal and upper ureteral calculi. Arch Ital Urol Androl, 2010. 82: 56.
https://pubmed.ncbi.nlm.nih.gov/20593724/
338. Cui, X., *et al*. Comparison between extracorporeal shock wave lithotripsy and ureteroscopic lithotripsy for treating large proximal ureteral stones: a meta-analysis. Urology, 2015. 85: 748.
https://pubmed.ncbi.nlm.nih.gov/25681251/
339. Ishii, H., *et al*. Outcomes of Systematic Review of Ureteroscopy for Stone Disease in the Obese and Morbidly Obese Population. J Endourol, 2016. 30: 135.
https://pubmed.ncbi.nlm.nih.gov/26415049/
340. Drake, T., *et al*. What are the Benefits and Harms of Ureteroscopy Compared with Shock-wave Lithotripsy in the Treatment of Upper Ureteral Stones? A Systematic Review. Eur Urol, 2017. 72: 772.
https://pubmed.ncbi.nlm.nih.gov/28456350/
341. Han, D.S., *et al*. The Durability of Active Surveillance in Patients with Asymptomatic Kidney Stones: A Systematic Review. J Endourol, 2019. 33: 598.
https://pubmed.ncbi.nlm.nih.gov/31044612/
342. Inci, K., *et al*. Prospective long-term followup of patients with asymptomatic lower pole caliceal stones. J Urol, 2007. 177: 2189.
https://pubmed.ncbi.nlm.nih.gov/17509315/
343. Brandt, B., *et al*. Painful caliceal calculi. The treatment of small nonobstructing caliceal calculi in patients with symptoms. Scand J Urol Nephrol, 1993. 27: 75.
https://pubmed.ncbi.nlm.nih.gov/8493473/
344. Burgher, A., *et al*. Progression of nephrolithiasis: long-term outcomes with observation of asymptomatic calculi. J Endourol, 2004. 18: 534.
https://pubmed.ncbi.nlm.nih.gov/15333216/
345. Hubner, W., *et al*. Treatment of caliceal calculi. Br J Urol, 1990. 66: 9.
https://pubmed.ncbi.nlm.nih.gov/2393803/

346. Keeley, F.X., Jr., *et al*. Preliminary results of a randomized controlled trial of prophylactic shock wave lithotripsy for small asymptomatic renal calyceal stones. BJU Int, 2001. 87: 1.
https://pubmed.ncbi.nlm.nih.gov/11121982/
347. Glowacki, L.S., *et al*. The natural history of asymptomatic urolithiasis. J Urol, 1992. 147: 319.
https://pubmed.ncbi.nlm.nih.gov/1732583/
348. Collins, J.W., *et al*. Is there a role for prophylactic shock wave lithotripsy for asymptomatic calyceal stones? Curr Opin Urol, 2002. 12: 281.
https://pubmed.ncbi.nlm.nih.gov/12072647/
349. Rebuck, D.A., *et al*. The natural history of renal stone fragments following ureteroscopy. Urology, 2011. 77: 564.
https://pubmed.ncbi.nlm.nih.gov/21109293/
350. Andersson, L., *et al*. Small renal caliceal calculi as a cause of pain. J Urol, 1983. 130: 752.
https://pubmed.ncbi.nlm.nih.gov/6887409/
351. Mee, S.L., *et al*. Small caliceal stones: is extracorporeal shock wave lithotripsy justified? J Urol, 1988. 139: 908.
https://pubmed.ncbi.nlm.nih.gov/3361660/
352. Argyropoulos, A.N., *et al*. Evaluation of outcome following lithotripsy. Curr Opin Urol, 2010. 20: 154.
https://pubmed.ncbi.nlm.nih.gov/19898239/
353. Srisubat, A., *et al*. Extracorporeal shock wave lithotripsy (ESWL) versus percutaneous nephrolithotomy (PCNL) or retrograde intrarenal surgery (RIRS) for kidney stones. Cochrane Database Syst Rev, 2014. 11: CD007044.
https://pubmed.ncbi.nlm.nih.gov/25418417/
354. Sahinkanat, T., *et al*. Evaluation of the effects of relationships between main spatial lower pole calyceal anatomic factors on the success of shock-wave lithotripsy in patients with lower pole kidney stones. Urology, 2008. 71: 801.
https://pubmed.ncbi.nlm.nih.gov/18279941/
355. Danuser, H., *et al*. Extracorporeal shock wave lithotripsy of lower calyx calculi: how much is treatment outcome influenced by the anatomy of the collecting system? Eur Urol, 2007. 52: 539.
https://pubmed.ncbi.nlm.nih.gov/17400366/
356. Preminger, G.M. Management of lower pole renal calculi: shock wave lithotripsy versus percutaneous nephrolithotomy versus flexible ureteroscopy. Urol Res, 2006. 34: 108.
https://pubmed.ncbi.nlm.nih.gov/16463145/
357. Zheng, C., *et al*. Extracorporeal shock wave lithotripsy versus retrograde intrarenal surgery for treatment for renal stones 1-2 cm: a meta-analysis. Urolithiasis, 2015. 43: 549.
https://pubmed.ncbi.nlm.nih.gov/26211003/
358. Zheng, C., *et al*. Retrograde intrarenal surgery versus percutaneous nephrolithotomy for treatment of renal stones >2 cm: a meta-analysis. Urol Int, 2014. 93: 417.
https://pubmed.ncbi.nlm.nih.gov/25170589/
359. Karakoyunlu, N., *et al*. A comparison of standard PCNL and staged retrograde FURS in pelvis stones over 2 cm in diameter: a prospective randomized study. Urolithiasis, 2015. 43: 283.
https://pubmed.ncbi.nlm.nih.gov/25838180/
360. Donaldson, J.F., *et al*. Systematic review and meta-analysis of the clinical effectiveness of shock wave lithotripsy, retrograde intrarenal surgery, and percutaneous nephrolithotomy for lower-pole renal stones. Eur Urol, 2015. 67: 612.
https://pubmed.ncbi.nlm.nih.gov/25449204/
361. Kumar, A., *et al*. A prospective, randomized comparison of shock wave lithotripsy, retrograde intrarenal surgery and miniperc for treatment of 1 to 2 cm radiolucent lower calyceal renal calculi: a single center experience. J Urol, 2015. 193: 160.
https://pubmed.ncbi.nlm.nih.gov/25066869/
362. Sener, N.C., *et al*. Prospective randomized trial comparing shock wave lithotripsy and flexible ureterorenoscopy for lower pole stones smaller than 1 cm. Urolithiasis, 2014. 42: 127.
https://pubmed.ncbi.nlm.nih.gov/24220692/
363. Manikandan, R., *et al*. Do anatomic factors pose a significant risk in the formation of lower pole stones? Urology, 2007. 69: 620.
https://pubmed.ncbi.nlm.nih.gov/17445636/
364. De, S., *et al*. Percutaneous nephrolithotomy versus retrograde intrarenal surgery: a systematic review and meta-analysis. Eur Urol, 2015. 67: 125.
https://pubmed.ncbi.nlm.nih.gov/25064687/

365. Sener, N.C., *et al*. Asymptomatic lower pole small renal stones: shock wave lithotripsy, flexible ureteroscopy, or observation? A prospective randomized trial. Urology, 2015. 85: 33.
https://pubmed.ncbi.nlm.nih.gov/25440816/
366. Kumar, A., *et al*. A Prospective Randomized Comparison Between Shock Wave Lithotripsy and Flexible Ureterorenoscopy for Lower Caliceal Stones </=2 cm: A Single-Center Experience. J Endourol, 2015. 29: 575.
https://pubmed.ncbi.nlm.nih.gov/25203489/
367. Mi, Y., *et al*. Flexible ureterorenoscopy (F-URS) with holmium laser versus extracorporeal shock wave lithotripsy (ESWL) for treatment of renal stone <2 cm: a meta-analysis. Urolithiasis, 2016. 44: 353.
https://pubmed.ncbi.nlm.nih.gov/26530230/
368. Zhang, W., *et al*. Retrograde Intrarenal Surgery Versus Percutaneous Nephrolithotomy Versus Extracorporeal Shockwave Lithotripsy for Treatment of Lower Pole Renal Stones: A Meta-Analysis and Systematic Review. J Endourol, 2015. 29: 745.
https://pubmed.ncbi.nlm.nih.gov/25531986/
369. Junbo, L., *et al*. Retrograde Intrarenal Surgery vs. Percutaneous Nephrolithotomy vs. Extracorporeal Shock Wave Lithotripsy for Lower Pole Renal Stones 10-20 mm : A Meta-analysis and Systematic Review. Urol J, 2019. 16: 97.
https://pubmed.ncbi.nlm.nih.gov/30604405/
370. Tsai, S.H., *et al*. Comparison of the efficacy and safety of shockwave lithotripsy, retrograde intrarenal surgery, percutaneous nephrolithotomy, and minimally invasive percutaneous nephrolithotomy for lower-pole renal stones: A systematic review and network meta-analysis. Medicine (Baltimore), 2020. 99: e19403.
https://pubmed.ncbi.nlm.nih.gov/32150088/
371. Zhang, H., *et al*. Comparison of the Efficacy of Ultra-Mini PCNL, Flexible Ureteroscopy, and Shock Wave Lithotripsy on the Treatment of 1-2 cm Lower Pole Renal Calculi. Urol Int, 2019. 102: 153.
https://pubmed.ncbi.nlm.nih.gov/30352443/
372. Kallidonis, P., *et al*. Systematic Review and Meta-Analysis Comparing Percutaneous Nephrolithotomy, Retrograde Intrarenal Surgery and Shock Wave Lithotripsy for Lower Pole Renal Stones Less Than 2 cm in Maximum Diameter. J Urol, 2020. 204: 427.
https://pubmed.ncbi.nlm.nih.gov/32150506/
373. Barone, B., *et al*. Retrograde intra renal surgery versus percutaneous nephrolithotomy for renal stones >2 cm. A systematic review and meta-analysis. Minerva Urol Nefrol, 2020. 72: 441.
https://pubmed.ncbi.nlm.nih.gov/32083423/
374. Torricelli, F.C.M., *et al*. Renal Stone Features Are More Important Than Renal Anatomy to Predict Shock Wave Lithotripsy Outcomes: Results from a Prospective Study with CT Follow-Up. J Endourol, 2020. 34: 63.
https://pubmed.ncbi.nlm.nih.gov/31595801/
375. Madbouly, K., *et al*. Impact of lower pole renal anatomy on stone clearance after shock wave lithotripsy: fact or fiction? J Urol, 2001. 165: 1415.
https://pubmed.ncbi.nlm.nih.gov/11342888/
376. Abdelhamid, M., *et al*. A Prospective Evaluation of High-Resolution CT Parameters in Predicting Extracorporeal Shockwave Lithotripsy Success for Upper Urinary Tract Calculi. J Endourol, 2016. 30: 1227.
https://pubmed.ncbi.nlm.nih.gov/27597174/
377. Gupta, N.P., *et al*. Infundibulopelvic anatomy and clearance of inferior caliceal calculi with shock wave lithotripsy. J Urol, 2000. 163: 24.
https://pubmed.ncbi.nlm.nih.gov/10604306/
378. Torricelli, F.C., *et al*. Impact of renal anatomy on shock wave lithotripsy outcomes for lower pole kidney stones: results of a prospective multifactorial analysis controlled by computerized tomography. J Urol, 2015. 193: 2002.
https://pubmed.ncbi.nlm.nih.gov/25524240/
379. Sumino, Y., *et al*. Predictors of lower pole renal stone clearance after extracorporeal shock wave lithotripsy. J Urol, 2002. 168: 1344.
https://pubmed.ncbi.nlm.nih.gov/12352389/
380. Chiong, E., *et al*. Randomized controlled study of mechanical percussion, diuresis, and inversion therapy to assist passage of lower pole renal calculi after shock wave lithotripsy. Urology, 2005. 65: 1070.
https://pubmed.ncbi.nlm.nih.gov/15922429/

381. Chan, L.H., *et al*. Primary SWL Is an Efficient and Cost-Effective Treatment for Lower Pole Renal Stones Between 10 and 20 mm in Size: A Large Single Center Study. J Endourol, 2017. 31: 510.
https://pubmed.ncbi.nlm.nih.gov/28355100/
382. Hyams, E.S., *et al*. Flexible ureterorenoscopy and holmium laser lithotripsy for the management of renal stone burdens that measure 2 to 3 cm: a multi-institutional experience. J Endourol, 2010. 24: 1583.
https://pubmed.ncbi.nlm.nih.gov/20629566/
383. Riley, J.M., *et al*. Retrograde ureteroscopy for renal stones larger than 2.5 cm. J Endourol, 2009. 23: 1395.
https://pubmed.ncbi.nlm.nih.gov/19694527/
384. Akman, T., *et al*. Comparison of percutaneous nephrolithotomy and retrograde flexible nephrolithotripsy for the management of 2-4 cm stones: a matched-pair analysis. BJU Int, 2012. 109: 1384.
https://pubmed.ncbi.nlm.nih.gov/22093679/
385. Assimos, D.G., *et al*. The role of open stone surgery since extracorporeal shock wave lithotripsy. J Urol, 1989. 142: 263.
https://pubmed.ncbi.nlm.nih.gov/2746742/
386. Segura, J.W. Current surgical approaches to nephrolithiasis. Endocrinol Metab Clin North Am, 1990. 19: 919.
https://pubmed.ncbi.nlm.nih.gov/2081519/
387. Honeck, P., *et al*. Does open stone surgery still play a role in the treatment of urolithiasis? Data of a primary urolithiasis center. J Endourol, 2009. 23: 1209.
https://pubmed.ncbi.nlm.nih.gov/19538063/
388. Bichler, K.H., *et al*. Indications for open stone removal of urinary calculi. Urol Int, 1997. 59: 102.
https://pubmed.ncbi.nlm.nih.gov/9392057/
389. Paik, M.L., *et al*. Is there a role for open stone surgery? Urol Clin North Am, 2000. 27: 323.
https://pubmed.ncbi.nlm.nih.gov/10778474/
390. Alivizatos, G., *et al*. Is there still a role for open surgery in the management of renal stones? Curr Opin Urol, 2006. 16: 106.
https://pubmed.ncbi.nlm.nih.gov/16479213/
391. Basiri, A., *et al*. Comparison of safety and efficacy of laparoscopic pyelolithotomy versus percutaneous nephrolithotomy in patients with renal pelvic stones: a randomized clinical trial. Urol J, 2014. 11: 1932.
https://pubmed.ncbi.nlm.nih.gov/25433470/
392. Prakash, J., *et al*. Retroperitoneoscopic versus open mini-incision ureterolithotomy for upper- and mid-ureteric stones: a prospective randomized study. Urolithiasis, 2014. 42: 133.
https://pubmed.ncbi.nlm.nih.gov/24272062/
393. Al-Hunayan, A., *et al*. Management of solitary renal pelvic stone: laparoscopic retroperitoneal pyelolithotomy versus percutaneous nephrolithotomy. J Endourol, 2011. 25: 975.
https://pubmed.ncbi.nlm.nih.gov/21612433/
394. Skolarikos, A., *et al*. Laparoscopic urinary stone surgery: an updated evidence-based review. Urol Res, 2010. 38: 337.
https://pubmed.ncbi.nlm.nih.gov/20396871/
395. Giedelman, C., *et al*. Laparoscopic anatrophic nephrolithotomy: developments of the technique in the era of minimally invasive surgery. J Endourol, 2012. 26: 444.
https://pubmed.ncbi.nlm.nih.gov/22142215/
396. Wang, X., *et al*. Laparoscopic pyelolithotomy compared to percutaneous nephrolithotomy as surgical management for large renal pelvic calculi: a meta-analysis. J Urol, 2013. 190: 888.
https://pubmed.ncbi.nlm.nih.gov/23454154/
397. Singh, V., *et al*. Prospective randomized comparison of retroperitoneoscopic pyelolithotomy versus percutaneous nephrolithotomy for solitary large pelvic kidney stones. Urol Int, 2014. 92: 392.
https://pubmed.ncbi.nlm.nih.gov/24135482/
398. Kumar, A., *et al*. A Prospective Randomized Comparison Between Laparoscopic Ureterolithotomy and Semirigid Ureteroscopy for Upper Ureteral Stones >2 cm: A Single-Center Experience. J Endourol, 2015. 29: 1248.
https://pubmed.ncbi.nlm.nih.gov/25177768/
399. Torricelli, F.C., *et al*. Semi-rigid ureteroscopic lithotripsy versus laparoscopic ureterolithotomy for large upper ureteral stones: a meta - analysis of randomized controlled trials. Int Braz J Urol, 2016. 42: 645.
https://pubmed.ncbi.nlm.nih.gov/27564273/

400. Hossein, S.M., *et al*. Stented Versus Stentless Laparoscopic Ureterolithotomy: A Systematic Review and Meta-Analysis. J Laparoen Adv Surg Tech, 2017. 27: 1269.
https://pubmed.ncbi.nlm.nih.gov/28631946/
401. Mao, T., *et al*. Efficacy and safety of laparoscopic pyelolithotomy versus percutaneous nephrolithotomy for treatment of large renal stones: a meta-analysis. J Int Med Res, 2021. 49: 300060520983136.
https://pubmed.ncbi.nlm.nih.gov/33472474/
402. Xiao, Y., *et al*. Perioperative and long-term results of retroperitoneal laparoscopic pyelolithotomy versus percutaneous nephrolithotomy for staghorn calculi: a single-center randomized controlled trial. World J Urol, 2019. 37: 1441.
https://pubmed.ncbi.nlm.nih.gov/30361956/
403. Muller, P.F., *et al*. Robotic stone surgery - Current state and future prospects: A systematic review. Arab J Urol, 2018. 16: 357.
https://pubmed.ncbi.nlm.nih.gov/30140470/
404. Coptcoat, M.J., *et al*. The steinstrasse: a legacy of extracorporeal lithotripsy? Eur Urol, 1988. 14: 93.
https://pubmed.ncbi.nlm.nih.gov/3360043/
405. Lucio, J., 2nd, *et al*. Steinstrasse predictive factors and outcomes after extracorporeal shockwave lithotripsy. Int Braz J Urol, 2011. 37: 477.
https://pubmed.ncbi.nlm.nih.gov/21888699/
406. Moursy, E., *et al*. Tamsulosin as an expulsive therapy for steinstrasse after extracorporeal shock wave lithotripsy: a randomized controlled study. Scand J Urol Nephrol, 2010. 44: 315.
https://pubmed.ncbi.nlm.nih.gov/20560802/
407. Resim, S., *et al*. Role of tamsulosin in treatment of patients with steinstrasse developing after extracorporeal shock wave lithotripsy. Urology, 2005. 66: 945.
https://pubmed.ncbi.nlm.nih.gov/16286100/
408. Rabbani, S.M. Treatment of steinstrasse by transureteral lithotripsy. Urol J, 2008. 5: 89.
https://pubmed.ncbi.nlm.nih.gov/18592460/
409. Chew, B.H., *et al*. Natural History, Complications and Re-Intervention Rates of Asymptomatic Residual Stone Fragments after Ureteroscopy: a Report from the EDGE Research Consortium. J Urol, 2016. 195: 982.
https://pubmed.ncbi.nlm.nih.gov/26585680/
410. Candau, C., *et al*. Natural history of residual renal stone fragments after ESWL. Eur Urol, 2000. 37: 18.
https://pubmed.ncbi.nlm.nih.gov/10671779/
411. Olvera-Posada, D., *et al*. Natural History of Residual Fragments After Percutaneous Nephrolithotomy: Evaluation of Factors Related to Clinical Events and Intervention. Urology, 2016. 97: 46.
https://pubmed.ncbi.nlm.nih.gov/27421779/
412. Portis, A.J., *et al*. Confident intraoperative decision making during percutaneous nephrolithotomy: does this patient need a second look? Urology, 2008. 71: 218.
https://pubmed.ncbi.nlm.nih.gov/18308087/
413. Tokas, T., *et al*. Uncovering the real outcomes of active renal stone treatment by utilizing non-contrast computer tomography: a systematic review of the current literature. World J Urol, 2017. 35: 897.
https://pubmed.ncbi.nlm.nih.gov/27738806/
414. Omar, M., *et al*. Contemporary Imaging Practice Patterns Following Ureteroscopy for Stone Disease. J Endourol, 2015. 29: 1122.
https://pubmed.ncbi.nlm.nih.gov/25963170/
415. Rippel, C.A., *et al*. Residual fragments following ureteroscopic lithotripsy: incidence and predictors on postoperative computerized tomography. J Urol, 2012. 188: 2246.
https://pubmed.ncbi.nlm.nih.gov/23083650/
416. Gokce, M.I., *et al*. Comparison of imaging modalities for detection of residual fragments and prediction of stone related events following percutaneous nephrolitotomy. Int Braz J Urol, 2015. 41: 86.
https://pubmed.ncbi.nlm.nih.gov/25928513/
417. Beck, E.M., *et al*. The fate of residual fragments after extracorporeal shock wave lithotripsy monotherapy of infection stones. J Urol, 1991. 145: 6.
https://pubmed.ncbi.nlm.nih.gov/1984100/
418. El-Nahas, A.R., *et al*. Predictors of clinical significance of residual fragments after extracorporeal shockwave lithotripsy for renal stones. J Endourol, 2006. 20: 870.
https://pubmed.ncbi.nlm.nih.gov/17144853/

419. Buchholz, N.P., *et al*. Minor residual fragments after extracorporeal shockwave lithotripsy: spontaneous clearance or risk factor for recurrent stone formation? J Endourol, 1997. 11: 227. https://pubmed.ncbi.nlm.nih.gov/9376838/
420. McKnoulty, M., *et al*. Spontaneous renal fornix rupture in pregnancy and the post partum period: a systematic review of outcomes and management. BMC Urology, 2020. 20: 116. https://pubmed.ncbi.nlm.nih.gov/32753038/
421. Tsai, Y.L., *et al*. Comparative study of conservative and surgical management for symptomatic moderate and severe hydronephrosis in pregnancy: a prospective randomized study. Acta Obstet Gynecol Scand, 2007. 86: 1047. https://pubmed.ncbi.nlm.nih.gov/17712643/
422. Mokhmalji, H., *et al*. Percutaneous nephrostomy versus ureteral stents for diversion of hydronephrosis caused by stones: a prospective, randomized clinical trial. J Urol, 2001. 165: 1088. https://pubmed.ncbi.nlm.nih.gov/11257644/
423. Dai, J.C., *et al*. Nephrolithiasis in Pregnancy: Treating for Two. Urology, 2021. 151: 44. https://pubmed.ncbi.nlm.nih.gov/32866511/
424. Ngai, H.Y., *et al*. Double-J ureteric stenting in pregnancy: A single-centre experience from Iraq. Arab J Urol, 2013. 11: 148. https://pubmed.ncbi.nlm.nih.gov/26558073/
425. Ishii, H., *et al*. Current status of ureteroscopy for stone disease in pregnancy. Urolithiasis, 2014. 42: 1. https://pubmed.ncbi.nlm.nih.gov/24374899/
426. Teleb, M., *et al*. Definitive ureteroscopy and intracorporeal lithotripsy in treatment of ureteral calculi during pregnancy. Arab J Urol, 2014. 12: 299. https://pubmed.ncbi.nlm.nih.gov/26019966/
427. Ramachandra, M., *et al*. Safety and feasibility of percutaneous nephrolithotomy (PCNL) during pregnancy: A review of literature. Turk J Urol, 2020. 46: 89. https://pubmed.ncbi.nlm.nih.gov/32134719/
428. Holmes, D.G., *et al*. Long-term complications related to the modified Indiana pouch. Urology, 2002. 60: 603. https://pubmed.ncbi.nlm.nih.gov/12385916/
429. Yang, W.J., *et al*. Long-term effects of ileal conduit urinary diversion on upper urinary tract in bladder cancer. Urology, 2006. 68: 324. https://pubmed.ncbi.nlm.nih.gov/16904445/
430. Assimos, D.G. Nephrolithiasis in patients with urinary diversion. J Urol, 1996. 155: 69. https://pubmed.ncbi.nlm.nih.gov/7490901/
431. Cohen, T.D., *et al*. Long-term incidence and risks for recurrent stones following contemporary management of upper tract calculi in patients with a urinary diversion. J Urol, 1996. 155: 62. https://pubmed.ncbi.nlm.nih.gov/7490899/
432. Deliveliotis, C., *et al*. Shockwave lithotripsy for urinary stones in patients with urinary diversion after radical cystectomy. J Endourol, 2002. 16: 717. https://pubmed.ncbi.nlm.nih.gov/12542873/
433. Ramachandra, M.N., *et al*. Challenges of Retrograde Ureteroscopy in Patients with Urinary Diversion: Outcomes and Lessons Learnt from a Systematic Review of Literature. Urol Int, 2018. 101: 249. https://pubmed.ncbi.nlm.nih.gov/29614503/
434. Stein, J.P., *et al*. Complications of the afferent antireflux valve mechanism in the Kock ileal reservoir. J Urol, 1996. 155: 1579. https://pubmed.ncbi.nlm.nih.gov/8627827/
435. Matlaga, B.R., *et al*. Computerized tomography guided access for percutaneous nephrostolithotomy. J Urol, 2003. 170: 45. https://pubmed.ncbi.nlm.nih.gov/12796641/
436. Hensle, T.W., *et al*. Preventing reservoir calculi after augmentation cystoplasty and continent urinary diversion: the influence of an irrigation protocol. BJU Int, 2004. 93: 585. https://pubmed.ncbi.nlm.nih.gov/15008735/
437. Raj, G.V., *et al*. The incidence of nephrolithiasis in patients with spinal neural tube defects. J Urol, 1999. 162: 1238. https://pubmed.ncbi.nlm.nih.gov/10458475/
438. Gros, D.A., *et al*. Urolithiasis in spina bifida. Eur J Pediatr Surg, 1998. 8 Suppl 1: 68. https://pubmed.ncbi.nlm.nih.gov/9926338/
439. Kondo, A., *et al*. [Urolithiasis in those patients with myelodysplasia]. Nihon Hinyokika Gakkai Zasshi, 2003. 94: 15. https://pubmed.ncbi.nlm.nih.gov/12638200/

440. Rendeli, C., *et al*. Latex sensitisation and allergy in children with myelomeningocele. Childs Nerv Syst, 2006. 22: 28.
https://pubmed.ncbi.nlm.nih.gov/15703967/
441. Christman, M.S., *et al*. Morbidity and efficacy of ureteroscopic stone treatment in patients with neurogenic bladder. J Urol, 2013. 190: 1479.
https://pubmed.ncbi.nlm.nih.gov/23454151/
442. Klingler, H.C., *et al*. Urolithiasis in allograft kidneys. Urology, 2002. 59: 344.
https://pubmed.ncbi.nlm.nih.gov/11880067/
443. Cheungpasitporn, W., *et al*. Incidence of kidney stones in kidney transplant recipients: A systematic review and meta-analysis. World J Transplant, 2016. 6: 790.
https://pubmed.ncbi.nlm.nih.gov/28058231/
444. Harper, J.M., *et al*. Risk factors for calculus formation in patients with renal transplants. Br J Urol, 1994. 74: 147.
https://pubmed.ncbi.nlm.nih.gov/7921929/
445. Challacombe, B., *et al*. Multimodal management of urolithiasis in renal transplantation. BJU Int, 2005. 96: 385.
https://pubmed.ncbi.nlm.nih.gov/16042735/
446. Rifaioglu, M.M., *et al*. Percutaneous management of stones in transplanted kidneys. Urology, 2008. 72: 508.
https://pubmed.ncbi.nlm.nih.gov/18653217/
447. Gupta, M., *et al*. Treatment of stones associated with complex or anomalous renal anatomy. Urol Clin North Am, 2007. 34: 431.
https://pubmed.ncbi.nlm.nih.gov/17678992/
448. Minon Cifuentes, J., *et al*. Percutaneous nephrolithotomy in transplanted kidney. Urology, 1991. 38: 232.
https://pubmed.ncbi.nlm.nih.gov/1887537/
449. Wyatt, J., *et al*. Treatment outcomes for percutaneous nephrolithotomy in renal allografts. J Endourol, 2009. 23: 1821.
https://pubmed.ncbi.nlm.nih.gov/19814697/
450. Lu, H.F., *et al*. Donor-gifted allograft urolithiasis: early percutaneous management. Urology, 2002. 59: 25.
https://pubmed.ncbi.nlm.nih.gov/11796274/
451. Del Pizzo, J.J., *et al*. Ureteroscopic evaluation in renal transplant recipients. J Endourol, 1998. 12: 135.
https://pubmed.ncbi.nlm.nih.gov/9607439/
452. Basiri, A., *et al*. Ureteroscopic management of urological complications after renal transplantation. Scand J Urol Nephrol, 2006. 40: 53.
https://pubmed.ncbi.nlm.nih.gov/16452057/
453. Reeves, T., *et al*. Donor and post-transplant ureteroscopy for stone disease in patients with renal transplant: evidence from a systematic review. Curr Opin Urol, 2019. 29: 548.
https://pubmed.ncbi.nlm.nih.gov/30855381/
454. Parkhomenko, E., *et al*. Percutaneous Management of Stone Containing Calyceal Diverticula: Associated Factors and Outcomes. J Urol, 2017. 198: 864.
https://pubmed.ncbi.nlm.nih.gov/28483573/
455. Bas, O., *et al*. Management of calyceal diverticular calculi: a comparison of percutaneous nephrolithotomy and flexible ureterorenoscopy. Urolithiasis, 2015. 43: 155.
https://pubmed.ncbi.nlm.nih.gov/25249328/
456. Gaur, D.D. Retroperitoneal endoscopic ureterolithotomy: our experience in 12 patients. J Endourol, 1993. 7: 501.
https://pubmed.ncbi.nlm.nih.gov/8124346/
457. Gaur, D.D., *et al*. Retroperitoneal laparoscopic pyelolithotomy. J Urol, 1994. 151: 927.
https://pubmed.ncbi.nlm.nih.gov/8126827/
458. Locke, D.R., *et al*. Extracorporeal shock-wave lithotripsy in horseshoe kidneys. Urology, 1990. 35: 407.
https://pubmed.ncbi.nlm.nih.gov/2336770/
459. Lavan, L., *et al*. Outcomes of ureteroscopy for stone disease in anomalous kidneys: a systematic review. World J Urol, 2020. 38: 1135.
https://pubmed.ncbi.nlm.nih.gov/31101967/
460. Chen, H., *et al*. No Wound for Stones <2 cm in Horseshoe Kidney: A Systematic Review of Comparative Studies. Urol Int, 2019. 103: 249.
https://pubmed.ncbi.nlm.nih.gov/31096234/

461. Salvi, M., *et al*. Active treatment of renal stones in pelvic ectopic kidney: systematic review of literature. Minerva Urol Nefrol, 2020. 72: 691.
https://pubmed.ncbi.nlm.nih.gov/32298068/
462. Gelet, A., *et al*. Endopyelotomy with the Acucise cutting balloon device. Early clinical experience. Eur Urol, 1997. 31: 389.
https://pubmed.ncbi.nlm.nih.gov/9187895/
463. Faerber, G.J., *et al*. Retrograde treatment of ureteropelvic junction obstruction using the ureteral cutting balloon catheter. J Urol, 1997. 157: 454.
https://pubmed.ncbi.nlm.nih.gov/8996330/
464. Berkman, D.S., *et al*. Treatment outcomes after endopyelotomy performed with or without simultaneous nephrolithotomy: 10-year experience. J Endourol, 2009. 23: 1409.
https://pubmed.ncbi.nlm.nih.gov/19694529/
465. Nakada, S.Y., *et al*. Retrospective analysis of the effect of crossing vessels on successful retrograde endopyelotomy outcomes using spiral computerized tomography angiography. J Urol, 1998. 159: 62.
https://pubmed.ncbi.nlm.nih.gov/9400437/
466. Skolarikos, A., *et al*. Ureteropelvic obstruction and renal stones: etiology and treatment. Urolithiasis, 2015. 43: 5.
https://pubmed.ncbi.nlm.nih.gov/25362543/
467. Ward, J.B., *et al*. Pediatric Urinary Stone Disease in the United States: The Urologic Diseases in America Project. Urology, 2019. 129: 180.
https://pubmed.ncbi.nlm.nih.gov/31005657/
468. Matlaga, B.R., *et al*. Epidemiologic insights into pediatric kidney stone disease. Urol Res, 2010. 38: 453.
https://pubmed.ncbi.nlm.nih.gov/20967433/
469. Alfandary, H., *et al*. Increasing Prevalence of Nephrolithiasis in Association with Increased Body Mass Index in Children: A Population Based Study. J Urol, 2018. 199: 1044.
https://pubmed.ncbi.nlm.nih.gov/29061537/
470. Novak, T.E., *et al*. Sex prevalence of pediatric kidney stone disease in the United States: an epidemiologic investigation. Urology, 2009. 74: 104.
https://pubmed.ncbi.nlm.nih.gov/19428065/
471. Bevill, M., *et al*. The Modern Metabolic Stone Evaluation in Children. Urology, 2017. 101: 15.
https://pubmed.ncbi.nlm.nih.gov/27838366/
472. Kovacevic, L., *et al*. From hypercalciuria to hypocitraturia--a shifting trend in pediatric urolithiasis? J Urol, 2012. 188: 1623.
https://pubmed.ncbi.nlm.nih.gov/22910255/
473. Cambareri, G.M., *et al*. National multi-institutional cooperative on urolithiasis in children: Age is a significant predictor of urine abnormalities. J Pediatr Urol, 2015. 11: 218.
https://pubmed.ncbi.nlm.nih.gov/26119451/
474. Braun, D.A., *et al*. Prevalence of Monogenic Causes in Pediatric Patients with Nephrolithiasis or Nephrocalcinosis. Clin J Am Soc Nephrol, 2016. 11: 664.
https://pubmed.ncbi.nlm.nih.gov/26787776/
475. Kant, A.K., *et al*. Contributors of water intake in US children and adolescents: associations with dietary and meal characteristics--National Health and Nutrition Examination Survey 2005-2006. Am J Clin Nutr, 2010. 92: 887.
https://pubmed.ncbi.nlm.nih.gov/20685949/
476. Cogswell, M.E., *et al*. Vital signs: sodium intake among U.S. school-aged children - 2009-2010. MMWR Morb Mortal Wkly Rep, 2014. 63: 789.
https://pubmed.ncbi.nlm.nih.gov/25211544/
477. Clark, M.A., *et al*. Nutritional quality of the diets of US public school children and the role of the school meal programs. J Am Diet Assoc, 2009. 109: S44.
https://pubmed.ncbi.nlm.nih.gov/19166672/
478. Andrioli, V., *et al*. Infant nephrolithiasis and nephrocalcinosis: Natural history and predictors of surgical intervention. J Pediatr Urol, 2017. 13: 355 e1.
https://pubmed.ncbi.nlm.nih.gov/28729176/
479. Sas, D.J., *et al*. Clinical, demographic, and laboratory characteristics of children with nephrolithiasis. Urolithiasis, 2016. 44: 241.
https://pubmed.ncbi.nlm.nih.gov/26467033/
480. Telli, O., *et al*. What happens to asymptomatic lower pole kidney stones smaller than 10 mm in children during watchful waiting? Pediatr Nephrol, 2017. 32: 853.
https://pubmed.ncbi.nlm.nih.gov/28070668/

481. Dos Santos, J., *et al*. Outcome Analysis of Asymptomatic Lower Pole Stones in Children. J Urol, 2016. 195: 1289.
https://pubmed.ncbi.nlm.nih.gov/26926554/
482. Dincel, N., *et al*. Are small residual stone fragments really insignificant in children? J Pediatr Surg, 2013. 48: 840.
https://pubmed.ncbi.nlm.nih.gov/23583144/
483. Tian, D., *et al*. The efficacy and safety of adrenergic alpha-antagonists in treatment of distal ureteral stones in pediatric patients: A systematic review and meta-analysis. J Pediatr Surg, 2017. 52: 360.
https://pubmed.ncbi.nlm.nih.gov/27837990/
484. Barreto, L., *et al*. Medical and surgical interventions for the treatment of urinary stones in children. Cochrane Database Syst Rev, 2018. 6: CD010784.
https://pubmed.ncbi.nlm.nih.gov/29859007/
485. Lu, P., *et al*. The clinical efficacy of extracorporeal shock wave lithotripsy in pediatric urolithiasis: a systematic review and meta-analysis. Urolithiasis, 2015. 43: 199.
https://pubmed.ncbi.nlm.nih.gov/25721456/
486. Dogan, H.S., *et al*. A new nomogram for prediction of outcome of pediatric shock-wave lithotripsy. J Pediatr Urol, 2015. 11: 84 e1.
https://pubmed.ncbi.nlm.nih.gov/25812469/
487. Alsagheer, G., *et al*. Extracorporeal shock wave lithotripsy (ESWL) monotherapy in children: Predictors of successful outcome. J Pediatr Urol, 2017. 13: 515 e1.
https://pubmed.ncbi.nlm.nih.gov/28457667/
488. Zeng, G., *et al*. Treatment of renal stones in infants: comparing extracorporeal shock wave lithotripsy and mini-percutaneous nephrolithotomy. Urol Res, 2012. 40: 599.
https://pubmed.ncbi.nlm.nih.gov/22580634/
489. Badawy, A.A., *et al*. Extracorporeal shock wave lithotripsy as first line treatment for urinary tract stones in children: outcome of 500 cases. Int Urol Nephrol, 2012. 44: 661.
https://pubmed.ncbi.nlm.nih.gov/22350835/
490. Jee, J.Y., *et al*. Efficacy of extracorporeal shock wave lithotripsy in pediatric and adolescent urolithiasis. Korean J Urol, 2013. 54: 865.
https://pubmed.ncbi.nlm.nih.gov/24363869/
491. Cevik, B., *et al*. Procedural sedation and analgesia for pediatric shock wave lithotripsy: a 10 year experience of single institution. Urolithiasis, 2018. 46: 363.
https://pubmed.ncbi.nlm.nih.gov/28642966/
492. Kumar, A., *et al*. A Single Center Experience Comparing Miniperc and Shockwave Lithotripsy for Treatment of Radiopaque 1-2 cm Lower Caliceal Renal Calculi in Children: A Prospective Randomized Study. J Endourol, 2015. 29: 805.
https://pubmed.ncbi.nlm.nih.gov/25633506/
493. Wang, H.H., *et al*. Shock wave lithotripsy vs ureteroscopy: variation in surgical management of kidney stones at freestanding children's hospitals. J Urol, 2012. 187: 1402.
https://pubmed.ncbi.nlm.nih.gov/22341283/
494. Jurkiewicz, B., *et al*. Ureterolithotripsy in a paediatric population: a single institution's experience. Urolithiasis, 2014. 42: 171.
https://pubmed.ncbi.nlm.nih.gov/24368682/
495. Elsheemy, M.S., *et al*. Holmium:YAG laser ureteroscopic lithotripsy for ureteric calculi in children: predictive factors for complications and success. World J Urol, 2014. 32: 985.
https://pubmed.ncbi.nlm.nih.gov/23979150/
496. Ishii, H., *et al*. Ureteroscopy for stone disease in the paediatric population: a systematic review. BJU Int, 2015. 115: 867.
https://pubmed.ncbi.nlm.nih.gov/25203925/
497. Tanriverdi, O., *et al*. Comparison of ureteroscopic procedures with rigid and semirigid ureteroscopes in pediatric population: does the caliber of instrument matter? Pediatr Surg Int, 2010. 26: 733.
https://pubmed.ncbi.nlm.nih.gov/20521057/
498. Dogan, H.S., *et al*. Factors affecting complication rates of ureteroscopic lithotripsy in children: results of multi-institutional retrospective analysis by Pediatric Stone Disease Study Group of Turk Pediatr Urol Soc. J Urol, 2011. 186: 1035.
https://pubmed.ncbi.nlm.nih.gov/21784482/
499. Gokce, M.I., *et al*. Effect of Prestenting on Success and Complication Rates of Ureterorenoscopy in Pediatric Population. J Endourol, 2016. 30: 850.
https://pubmed.ncbi.nlm.nih.gov/27189236/

500. Ellison, J.S., *et al*. Risk factors for repeat surgical intervention in pediatric nephrolithiasis: A Pediatric Health Information System database study. J Pediatr Urol, 2018. 14: 245 e1.
https://pubmed.ncbi.nlm.nih.gov/29580730/
501. Unsal, A., *et al*. Retrograde intrarenal surgery in infants and preschool-age children. J Pediatr Surg, 2011. 46: 2195.
https://pubmed.ncbi.nlm.nih.gov/22075358/
502. Erkurt, B., *et al*. Treatment of renal stones with flexible ureteroscopy in preschool age children. Urolithiasis, 2014. 42: 241.
https://pubmed.ncbi.nlm.nih.gov/24374900/
503. Suliman, A., *et al*. Flexible ureterorenoscopy to treat upper urinary tract stones in children. Urolithiasis, 2018.
https://pubmed.ncbi.nlm.nih.gov/30370467/
504. Xiao, J., *et al*. Treatment of upper urinary tract stones with flexible ureteroscopy in children. Can Urol Assoc J, 2018.
https://pubmed.ncbi.nlm.nih.gov/30169147/
505. Tiryaki, T., *et al*. Ureteroscopy for treatment of ureteral stones in children: factors influencing the outcome. Urology, 2013. 81: 1047.
https://pubmed.ncbi.nlm.nih.gov/23465154/
506. Mokhless, I.A., *et al*. Retrograde intrarenal surgery monotherapy versus shock wave lithotripsy for stones 10 to 20 mm in preschool children: a prospective, randomized study. J Urol, 2014. 191: 1496.
https://pubmed.ncbi.nlm.nih.gov/24679882/
507. Saad, K.S., *et al*. Percutaneous Nephrolithotomy vs Retrograde Intrarenal Surgery for Large Renal Stones in Pediatric Patients: A Randomized Controlled Trial. J Urol, 2015. 194: 1716.
https://pubmed.ncbi.nlm.nih.gov/26165587/
508. Pelit, E.S., *et al*. Comparison of Mini-percutaneous Nephrolithotomy and Retrograde Intrarenal Surgery in Preschool-aged Children. Urology, 2017. 101: 21.
https://pubmed.ncbi.nlm.nih.gov/27818164/
509. Bas, O., *et al*. Comparison of Retrograde Intrarenal Surgery and Micro-Percutaneous Nephrolithotomy in Moderately Sized Pediatric Kidney Stones. J Endourol, 2016. 30: 765.
https://pubmed.ncbi.nlm.nih.gov/26983791/
510. Chen, Y., *et al*. Percutaneous nephrolithotomy versus retrograde intrarenal surgery for pediatric patients with upper urinary stones: a systematic review and meta-analysis. Urolithiasis, 2018.
https://pubmed.ncbi.nlm.nih.gov/29368009/
511. Cicekbilek, I., *et al*. Effect of percutaneous nephrolithotomy on renal functions in children: assessment by quantitative SPECT of (99m)Tc-DMSA uptake by the kidneys. Ren Fail, 2015. 37: 1118.
https://pubmed.ncbi.nlm.nih.gov/26067745/
512. Celik, H., *et al*. Comparison of the results of pediatric percutaneous nephrolithotomy with different sized instruments. Urolithiasis, 2017. 45: 203.
https://pubmed.ncbi.nlm.nih.gov/27155829/
513. Dombrovskiy, V., *et al*. Percutaneous Nephrolithotomy in Children: Analysis of Nationwide Hospitalizations and Short-Term Outcomes for the United States, 2001-2014. J Endourol, 2018. 32: 912.
https://pubmed.ncbi.nlm.nih.gov/30113212/
514. Senocak, C., *et al*. Predictive factors of bleeding among pediatric patients undergoing percutaneous nephrolithotomy. Urolithiasis, 2018. 46: 383.
https://pubmed.ncbi.nlm.nih.gov/28702679/
515. Jones, P., *et al*. Role of Minimally Invasive Percutaneous Nephrolithotomy Techniques-Micro and Ultra-Mini PCNL (<15F) in the Pediatric Population: A Systematic Review. J Endourol, 2017. 31: 816.
https://pubmed.ncbi.nlm.nih.gov/28478724/
516. Guven, S., *et al*. Percutaneous nephrolithotomy in children in different age groups: data from the Clinical Research Office of the Endourological Society (CROES) Percutaneous Nephrolithotomy Global Study. BJU Int, 2013. 111: 148.
https://pubmed.ncbi.nlm.nih.gov/22578216/
517. Onal, B., *et al*. Factors affecting complication rates of percutaneous nephrolithotomy in children: results of a multi-institutional retrospective analysis by the Turkish pediatric urology society. J Urol, 2014. 191: 777.
https://pubmed.ncbi.nlm.nih.gov/24095906/
518. Aghamir, S.M., *et al*. Comparing Bleeding Complications of Double and Single Access Totally Tubeless PCNL: Is It Safe to Obtain More Accesses? Urol Int, 2016. 96: 73.
https://pubmed.ncbi.nlm.nih.gov/26021886/

519. Iqbal, N., *et al*. Comparison of outcomes of tubed versus tubeless percutaneous nephrolithotomy in children: A single center study. Turk J Urol, 2018. 44: 56.
https://pubmed.ncbi.nlm.nih.gov/29484229/
520. Samad, L., *et al*. Does percutaneous nephrolithotomy in children cause significant renal scarring? J Pediatr Urol, 2007. 3: 36.
https://pubmed.ncbi.nlm.nih.gov/18947696/
521. Modi, P.K., *et al*. Pediatric hospitalizations for upper urinary tract calculi: Epidemiological and treatment trends in the United States, 2001-2014. J Pediatr Urol, 2018. 14: 13 e1.
https://pubmed.ncbi.nlm.nih.gov/28966022/
522. Agrawal, V., *et al*. Laparoscopic management of pediatric renal and ureteric stones. J Pediatr Urol, 2013. 9: 230.
https://pubmed.ncbi.nlm.nih.gov/22498008/
523. Srivastava, A., *et al*. Laparoscopic Ureterolithotomy in Children: With and Without Stent - Initial Tertiary Care Center Experience with More Than 1-Year Follow-Up. Eur J Pediatr Surg, 2017. 27: 150.
https://pubmed.ncbi.nlm.nih.gov/26878339/
524. Lee, R.S., *et al*. Early results of robot assisted laparoscopic lithotomy in adolescents. J Urol, 2007. 177: 2306.
https://pubmed.ncbi.nlm.nih.gov/17509345/
525. Dai, J.C., *et al*. National Trends in CT Utilization and Estimated CT-related Radiation Exposure in the Evaluation and Follow-up of Stone Patients. Urology, 2019. 133: 50.
https://pubmed.ncbi.nlm.nih.gov/31404583/
526. Vassileva, J., *et al*. Radiation exposure of patients during endourological procedures: IAEA-SEGUR study. J Radiol Prot, 2020.
https://pubmed.ncbi.nlm.nih.gov/33086202/
527. Yecies, T., *et al*. Identifying and managing the risks of medical ionizing radiation in endourology. Can J Urol, 2018. 25: 9154.
https://pubmed.ncbi.nlm.nih.gov/29524969/
528. Jindal, T. The risk of radiation exposure to assisting staff in urological procedures: a literature review. Urol Nurs, 2013. 33: 136.
https://pubmed.ncbi.nlm.nih.gov/23930446/
529. Vassileva, J., *et al*. Radiation Exposure of Surgical Team During Endourological Procedures: International Atomic Energy Agency-South-Eastern European Group for Urolithiasis Research Study. J Endourol, 2021. 35: 574.
https://pubmed.ncbi.nlm.nih.gov/32791856/
530. Pierce, D.A., *et al*. Radiation-related cancer risks at low doses among atomic bomb survivors. Radiat Res, 2000. 154: 178.
https://pubmed.ncbi.nlm.nih.gov/10931690/
531. Preston, D.L., *et al*. Solid cancer incidence in atomic bomb survivors: 1958-1998. Radiat Res, 2007. 168: 1.
https://pubmed.ncbi.nlm.nih.gov/17722996/
532. Pearce, M.S., *et al*. Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours: a retrospective cohort study. Lancet, 2012. 380: 499.
https://pubmed.ncbi.nlm.nih.gov/22681860/
533. Mathews, J.D., *et al*. Cancer risk in 680,000 people exposed to computed tomography scans in childhood or adolescence: data linkage study of 11 million Australians. BMJ, 2013. 346: f2360.
https://pubmed.ncbi.nlm.nih.gov/23694687/
534. Berrington de González, A., *et al*. Projected cancer risks from computed tomographic scans performed in the United States in 2007. Arch Intern Med, 2009. 169: 2071.
https://pubmed.ncbi.nlm.nih.gov/20008689/
535. Brenner, D.J., *et al*. Computed tomography--an increasing source of radiation exposure. N Engl J Med, 2007. 357: 2277.
https://pubmed.ncbi.nlm.nih.gov/18046031/
536. Wrixon, A.D. New ICRP recommendations. J Radiol Prot, 2008. 28: 161.
https://pubmed.ncbi.nlm.nih.gov/18495983/
537. Kim, C.H., *et al*. Are Urologists Performing Semi-rigid Ureteroscopic Lithotripsy Safe From Radiation Exposure? A Guidance to Reduce the Radiation Dose. Urology, 2016. 95: 54.
https://pubmed.ncbi.nlm.nih.gov/27289024/

538. Singh, V., *et al*. Prospective randomized comparison between fluoroscopy-guided ureteroscopy versus ureteroscopy with real-time ultrasonography for the management of ureteral stones. Urol Ann, 2016. 8: 418.
https://pubmed.ncbi.nlm.nih.gov/28057984/
539. Mohey, A., *et al*. Fluoroless-ureteroscopy for definitive management of distal ureteral calculi: randomized controlled trial. Can J Urol, 2018. 25: 9205.
https://pubmed.ncbi.nlm.nih.gov/29524976/
540. Subiela, J.D., *et al*. Systematic Review and Meta-Analysis Comparing Fluoroless Ureteroscopy and Conventional Ureteroscopy in the Management of Ureteral and Renal Stones. J Endourol, 2021. 35: 417.
https://pubmed.ncbi.nlm.nih.gov/33076706/
541. Peng, L., *et al*. Fluoroless versus conventional ureteroscopy for urinary stones: a systematic review and meta-analysis. Minerva Urol Nephrol, 2021. 73: 299.
https://pubmed.ncbi.nlm.nih.gov/33016033/
542. Parks, J.H., *et al*. A single 24-hour urine collection is inadequate for the medical evaluation of nephrolithiasis. J Urol, 2002. 167: 1607.
https://pubmed.ncbi.nlm.nih.gov/11912373/
543. Nayan, M., *et al*. Variations between two 24-hour urine collections in patients presenting to a tertiary stone clinic. Can Urol Assoc J, 2012. 6: 30.
https://pubmed.ncbi.nlm.nih.gov/22396364/
544. Williams, J.C., Jr., *et al*. Urine and stone analysis for the investigation of the renal stone former: a consensus conference. Urolithiasis, 2021. 49: 1.
https://pubmed.ncbi.nlm.nih.gov/33048172/
545. Ferraz, R.R., *et al*. Preservation of urine samples for metabolic evaluation of stone-forming patients. Urol Res, 2006. 34: 329.
https://pubmed.ncbi.nlm.nih.gov/16896690/
546. Porowski, T., *et al*. Assessment of Lithogenic Risk in Children Based on a Morning Spot Urine Sample. J Urol, 2010. 184: 2103.
https://pubmed.ncbi.nlm.nih.gov/20850811/
547. Coe, F.L., *et al*. Kidney stone disease. J Clin Invest, 2005. 115: 2598.
https://pubmed.ncbi.nlm.nih.gov/16200192/
548. Norman, R.W., *et al*. When should patients with symptomatic urinary stone disease be evaluated metabolically? J Urol, 1984. 132: 1137.
https://pubmed.ncbi.nlm.nih.gov/6502804/
549. Urine evaluation (in: Evaluation of the stone former), In: 2ND International Consultation on Stone Disease, H.M. Assimos D. Chew B, Hautmann R, Holmes R, Williams J, Wolf JS, Editor. 2007, Health Publications.
https://www.researchgate.net/publication/260000334
550. Hesse A, *et al*. Urinary Stones: Diagnosis, Treatment and Prevention of Recurrence., In: Uric acid stones. 2002, S Karger AG,: Basel.
https://www.karger.com/Article/Pdf/232951
551. Tiselius, H.G. Standardized estimate of the ion activity product of calcium oxalate in urine from renal stone formers. Eur Urol, 1989. 16: 48.
https://pubmed.ncbi.nlm.nih.gov/2714318/
552. Ackermann, D., *et al*. Use of the computer program EQUIL to estimate pH in model solutions and human urine. Urol Res, 1989. 17: 157.
https://pubmed.ncbi.nlm.nih.gov/2749945/
553. Kavanagh, J.P., *et al*. Why does the Bonn Risk Index discriminate between calcium oxalate stone formers and healthy controls? J Urol, 2006. 175: 766.
https://pubmed.ncbi.nlm.nih.gov/16407047/
554. Rodgers A.L., *et al*. JESS: What can it teach us?, In: Proceedings of Renal Stone Disease 1st Annual International Urolithiasis Research Symposium, 2-3 November 2006., A.P. Evan, Jr, Editor. 2007, American Institute of Physics: Melville, New York
https://ui.adsabs.harvard.edu/abs/2007AIPC..900..183R/abstract
555. Hoppe, B., *et al*. Diagnostic examination of the child with urolithiasis or nephrocalcinosis. Pediatr Nephrol, 2010. 25: 403.
https://pubmed.ncbi.nlm.nih.gov/19104842/
556. Sarica, K., *et al*. The effect of calcium channel blockers on stone regrowth and recurrence after shock wave lithotripsy. Urol Res, 2006. 34: 184.
https://pubmed.ncbi.nlm.nih.gov/16463053/

557. Fink, H.A., *et al*. Medical management to prevent recurrent nephrolithiasis in adults: a systematic review for an American College of Physicians Clinical Guideline. Ann Intern Med, 2013. 158: 535. https://pubmed.ncbi.nlm.nih.gov/23546565/
558. Borghi, L., *et al*. Urinary volume, water and recurrences in idiopathic calcium nephrolithiasis: a 5-year randomized prospective study. J Urol, 1996. 155: 839. https://pubmed.ncbi.nlm.nih.gov/8583588/
559. Bao, Y., *et al*. Water for preventing urinary stones. Cochrane Database Syst Rev, 2012: Cd004292. https://pubmed.ncbi.nlm.nih.gov/22696340/
560. Siener, R., *et al*. Dietary risk factors for hyperoxaluria in calcium oxalate stone formers. Kidney Int, 2003. 63: 1037. https://pubmed.ncbi.nlm.nih.gov/12631085/
561. Wabner, C.L., *et al*. Effect of orange juice consumption on urinary stone risk factors. J Urol, 1993. 149: 1405. https://pubmed.ncbi.nlm.nih.gov/8501777/
562. Gettman, M.T., *et al*. Effect of cranberry juice consumption on urinary stone risk factors. J Urol, 2005. 174: 590. https://pubmed.ncbi.nlm.nih.gov/16006907/
563. Shuster, J., *et al*. Soft drink consumption and urinary stone recurrence: a randomized prevention trial. J Clin Epidemiol, 1992. 45: 911. https://pubmed.ncbi.nlm.nih.gov/1624973/
564. Ferraro, P.M., *et al*. Soda and other beverages and the risk of kidney stones. Clin J Am Soc Nephrol, 2013. 8: 1389. https://pubmed.ncbi.nlm.nih.gov/23676355/
565. Kocvara, R., *et al*. A prospective study of nonmedical prophylaxis after a first kidney stone. BJU Int, 1999. 84: 393. https://pubmed.ncbi.nlm.nih.gov/10468751/
566. Hess, B., *et al*. Effects of a 'common sense diet' on urinary composition and supersaturation in patients with idiopathic calcium urolithiasis. Eur Urol, 1999. 36: 136. https://pubmed.ncbi.nlm.nih.gov/10420035/
567. Ebisuno, S., *et al*. Results of long-term rice bran treatment on stone recurrence in hypercalciuric patients. Br J Urol, 1991. 67: 237. https://pubmed.ncbi.nlm.nih.gov/1902388/
568. Hiatt, R.A., *et al*. Randomized controlled trial of a low animal protein, high fiber diet in the prevention of recurrent calcium oxalate kidney stones. Am J Epidemiol, 1996. 144: 25. https://pubmed.ncbi.nlm.nih.gov/8659482/
569. Dussol, B., *et al*. A randomized trial of low-animal-protein or high-fiber diets for secondary prevention of calcium nephrolithiasis. Nephron Clin Pract, 2008. 110: c185. https://pubmed.ncbi.nlm.nih.gov/18957869/
570. Turney, B.W., *et al*. Diet and risk of kidney stones in the Oxford cohort of the European Prospective Investigation into Cancer and Nutrition (EPIC). Eur J Epidemiol, 2014. 29: 363. https://pubmed.ncbi.nlm.nih.gov/24752465/
571. Asplin, J.R. The management of patients with enteric hyperoxaluria. Urolithiasis, 2016. 44: 33. https://pubmed.ncbi.nlm.nih.gov/26645872/
572. Ferraro, P.M., *et al*. Total, Dietary, and Supplemental Vitamin C Intake and Risk of Incident Kidney Stones. Am J Kidney Dis, 2016. 67: 400. https://pubmed.ncbi.nlm.nih.gov/26463139/
573. Fink, H.A., *et al*. Diet, fluid, or supplements for secondary prevention of nephrolithiasis: a systematic review and meta-analysis of randomized trials. Eur Urol, 2009. 56: 72. https://pubmed.ncbi.nlm.nih.gov/19321253/
574. Borghi, L., *et al*. Comparison of two diets for the prevention of recurrent stones in idiopathic hypercalciuria. N Engl J Med, 2002. 346: 77. https://pubmed.ncbi.nlm.nih.gov/11784873/
575. Curhan, G.C., *et al*. Comparison of dietary calcium with supplemental calcium and other nutrients as factors affecting the risk for kidney stones in women. Ann Intern Med, 1997. 126: 497. https://pubmed.ncbi.nlm.nih.gov/9092314/
576. von Unruh, G.E., *et al*. Dependence of oxalate absorption on the daily calcium intake. J Am Soc Nephrol, 2004. 15: 1567. https://pubmed.ncbi.nlm.nih.gov/15153567/

577. Harris, S.S., *et al*. Effects of Hydration and Calcium Supplementation on Urine Calcium Concentration in Healthy Postmenopausal Women. J Am Coll Nutr, 2015. 34: 340. https://pubmed.ncbi.nlm.nih.gov/25856469/
578. Coe F.M., *et al*. Hyperuricosuric calcium stone disease, In: Kidney Stones: Medical and Surgical Management, F.M. Coe FL, Pak CYC, Parks JH, Preminger GM, Editor. 1996, Lippincott-Raven: Philadelphia. https://www.geneeskundeboek.nl/kidney-stones-9789351529422
579. Coe, F.L. Hyperuricosuric calcium oxalate nephrolithiasis. Adv Exp Med Biol, 1980. 128: 439. https://pubmed.ncbi.nlm.nih.gov/7424690/
580. Siener, R., *et al*. The role of overweight and obesity in calcium oxalate stone formation. Obes Res, 2004. 12: 106. https://pubmed.ncbi.nlm.nih.gov/14742848/
581. Madore, F., *et al*. Nephrolithiasis and risk of hypertension. Am J Hypertens, 1998. 11: 46. https://pubmed.ncbi.nlm.nih.gov/9504449/
582. Madore, F., *et al*. Nephrolithiasis and risk of hypertension in women. Am J Kidney Dis, 1998. 32: 802. https://pubmed.ncbi.nlm.nih.gov/9820450/
583. Pearle, M.S., *et al*., Medical management of urolithiasis. In: 2ND International Consultation on Stone Disease, ed. K.S. Denstedt J. 2008. https://www.researchgate.net/publication/260000334
584. Barcelo, P., *et al*. Randomized double-blind study of potassium citrate in idiopathic hypocitraturic calcium nephrolithiasis. J Urol, 1993. 150: 1761. https://pubmed.ncbi.nlm.nih.gov/8230497/
585. Hofbauer, J., *et al*. Alkali citrate prophylaxis in idiopathic recurrent calcium oxalate urolithiasis--a prospective randomized study. Br J Urol, 1994. 73: 362. https://pubmed.ncbi.nlm.nih.gov/8199822/
586. Ettinger, B., *et al*. Potassium-magnesium citrate is an effective prophylaxis against recurrent calcium oxalate nephrolithiasis. J Urol, 1997. 158: 2069. https://pubmed.ncbi.nlm.nih.gov/9366314/
587. Lojanapiwat, B., *et al*. Alkaline citrate reduces stone recurrence and regrowth after shockwave lithotripsy and percutaneous nephrolithotomy. Int Braz J Urol, 2011. 37: 611. https://pubmed.ncbi.nlm.nih.gov/22099273/
588. Phillips, R., *et al*. Citrate salts for preventing and treating calcium containing kidney stones in adults. Cochrane Database Syst Rev, 2015: CD010057. https://pubmed.ncbi.nlm.nih.gov/26439475/
589. Favus, M.J., *et al*. The effects of allopurinol treatment on stone formation on hyperuricosuric calcium oxalate stone-formers. Scand J Urol Nephrol Suppl, 1980. 53: 265. https://pubmed.ncbi.nlm.nih.gov/6938003/
590. Ettinger, B., *et al*. Randomized trial of allopurinol in the prevention of calcium oxalate calculi. N Engl J Med, 1986. 315: 1386. https://pubmed.ncbi.nlm.nih.gov/3534570/
591. Smith, M.J. Placebo versus allopurinol for renal calculi. J Urol, 1977. 117: 690. https://pubmed.ncbi.nlm.nih.gov/875139/
592. Pearle, M.S., *et al*. Meta-analysis of randomized trials for medical prevention of calcium oxalate nephrolithiasis. J Endourol, 1999. 13: 679. https://pubmed.ncbi.nlm.nih.gov/10608521/
593. Cohen, T.D., *et al*. Clinical effect of captopril on the formation and growth of cystine calculi. J Urol, 1995. 154: 164. https://pubmed.ncbi.nlm.nih.gov/7776415/
594. Coulthard, M.G., *et al*. The treatment of cystinuria with captopril. Am J Kidney Dis, 1995. 25: 661. https://pubmed.ncbi.nlm.nih.gov/7702068/
595. Goldfarb, D.S., *et al*. Randomized controlled trial of febuxostat versus allopurinol or placebo in individuals with higher urinary uric acid excretion and calcium stones. Clin J Am Soc Nephrol, 2013. 8: 1960. https://pubmed.ncbi.nlm.nih.gov/23929928/
596. Nouvenne, A., *et al*. New pharmacologic approach to patients with idiopathic calcium nephrolithiasis and high uricosuria: Febuxostat vs allopurinol. A pilot study. Eur J Intern Med, 2013. 24: e64. https://www.cochranelibrary.com/central/doi/10.1002/central/CN-01024479/full
597. Jarrar, K., Boedeker, R. H. and Weidner, W. Struvite stones: long term follow up under metaphylaxis. Ann Urol (Paris), 1996. 30: 112. https://pubmed.ncbi.nlm.nih.gov/8766146/

598. Ettinger, B., *et al*. Chlorthalidone reduces calcium oxalate calculous recurrence but magnesium hydroxide does not. J Urol, 1988. 139: 679.
https://pubmed.ncbi.nlm.nih.gov/3280829/
599. Prien, E.L., Sr., *et al*. Magnesium oxide-pyridoxine therapy for recurrent calcium oxalate calculi. J Urol, 1974. 112: 509.
https://pubmed.ncbi.nlm.nih.gov/4414543/
600. Pinheiro, V.B., *et al*. The effect of sodium bicarbonate upon urinary citrate excretion in calcium stone formers. Urology, 2013. 82: 33.
https://pubmed.ncbi.nlm.nih.gov/23602798/
601. Hoppe, B., *et al*. The primary hyperoxalurias. Kidney Int, 2009. 75: 1264.
https://pubmed.ncbi.nlm.nih.gov/19225556/
602. Borghi, L., *et al*. Randomized prospective study of a nonthiazide diuretic, indapamide, in preventing calcium stone recurrences. J Cardiovasc Pharmacol, 1993. 22 Suppl 6: S78.
https://pubmed.ncbi.nlm.nih.gov/7508066/
603. Brocks, P., *et al*. Do thiazides prevent recurrent idiopathic renal calcium stones? Lancet, 1981. 2: 124.
https://pubmed.ncbi.nlm.nih.gov/6113485/
604. Mortensen, J.T., *et al*. Thiazides in the prophylactic treatment of recurrent idiopathic kidney stones. Int Urol Nephrol, 1986. 18: 265.
https://pubmed.ncbi.nlm.nih.gov/3533825/
605. Laerum, E., *et al*. Thiazide prophylaxis of urolithiasis. A double-blind study in general practice. Acta Med Scand, 1984. 215: 383.
https://pubmed.ncbi.nlm.nih.gov/6375276/
606. Ohkawa, M., *et al*. Thiazide treatment for calcium urolithiasis in patients with idiopathic hypercalciuria. Br J Urol, 1992. 69: 571.
https://pubmed.ncbi.nlm.nih.gov/1638340/
607. Scholz, D., *et al*. Double-blind study with thiazide in recurrent calcium lithiasis. J Urol, 1982. 128: 903.
https://pubmed.ncbi.nlm.nih.gov/7176047/
608. Nicar, M.J., *et al*. Use of potassium citrate as potassium supplement during thiazide therapy of calcium nephrolithiasis. J Urol, 1984. 131: 430.
https://pubmed.ncbi.nlm.nih.gov/6699979/
609. Fernandez-Rodriguez, A., *et al*. [The role of thiazides in the prophylaxis of recurrent calcium lithiasis]. Actas Urol Esp, 2006. 30: 305.
https://pubmed.ncbi.nlm.nih.gov/16749588/
610. Dolin, D.J., *et al*. Effect of cystine-binding thiol drugs on urinary cystine capacity in patients with cystinuria. J Endourol, 2005. 19: 429.
https://pubmed.ncbi.nlm.nih.gov/15865542/
611. Chow, G.K., *et al*. Medical treatment of cystinuria: results of contemporary clinical practice. J Urol, 1996. 156: 1576.
https://pubmed.ncbi.nlm.nih.gov/8863541/
612. Pak, C.Y., *et al*. Management of cystine nephrolithiasis with alpha-mercaptopropionylglycine. J Urol, 1986. 136: 1003.
https://pubmed.ncbi.nlm.nih.gov/3534301/
613. Tekin, A., *et al*. Cystine calculi in children: the results of a metabolic evaluation and response to medical therapy. J Urol, 2001. 165: 2328.
https://pubmed.ncbi.nlm.nih.gov/11371943/
614. Pedersen, S.A., *et al*. Hydrochlorothiazide use and risk of nonmelanoma skin cancer: A nationwide case-control study from Denmark. J Am Acad Dermatol, 2018. 78: 673.
https://pubmed.ncbi.nlm.nih.gov/29217346/
615. Pottegård, A., *et al*. Hydrochlorothiazide use is strongly associated with risk of lip cancer. J Intern Med, 2017. 282: 322.
https://pubmed.ncbi.nlm.nih.gov/28480532/
616. Worcester, E.M., *et al*. New insights into the pathogenesis of idiopathic hypercalciuria. Semin Nephrol, 2008. 28: 120.
https://pubmed.ncbi.nlm.nih.gov/18359393/
617. Curhan, G.C., *et al*. A prospective study of dietary calcium and other nutrients and the risk of symptomatic kidney stones. N Engl J Med, 1993. 328: 833.
https://pubmed.ncbi.nlm.nih.gov/8441427/
618. Wolf, H., *et al*. Do thiazides prevent recurrent idiopathic renal calcium oxalate stones? Proc Eur Dial Transplant Assoc, 1983. 20: 477.
https://pubmed.ncbi.nlm.nih.gov/6361755/

619. Johansson, G., *et al*. Effects of magnesium hydroxide in renal stone disease. J Am Coll Nutr, 1982. 1: 179.
https://pubmed.ncbi.nlm.nih.gov/6764473/
620. Khan, S.R., *et al*. Magnesium oxide administration and prevention of calcium oxalate nephrolithiasis. J Urol, 1993. 149: 412.
https://pubmed.ncbi.nlm.nih.gov/8426432/
621. Hesse, A., *et al*. Causes of phosphate stone formation and the importance of metaphylaxis by urinary acidification: a review. World J Urol, 1999. 17: 308.
https://pubmed.ncbi.nlm.nih.gov/10552150/
622. Silverberg, S.J., *et al*. A 10-year prospective study of primary hyperparathyroidism with or without parathyroid surgery. N Engl J Med, 1999. 341: 1249.
https://pubmed.ncbi.nlm.nih.gov/10528034/
623. Mollerup, C.L., *et al*. Risk of renal stone events in primary hyperparathyroidism before and after parathyroid surgery: controlled retrospective follow up study. BMJ, 2002. 325: 807.
https://pubmed.ncbi.nlm.nih.gov/12376441/
624. Evan, A.E., *et al*. Histopathology and surgical anatomy of patients with primary hyperparathyroidism and calcium phosphate stones. Kidney Int, 2008. 74: 223.
https://pubmed.ncbi.nlm.nih.gov/18449170/
625. Rizzato, G., *et al*. Nephrolithiasis as a presenting feature of chronic sarcoidosis: a prospective study. Sarcoidosis Vasc Diffuse Lung Dis, 1996. 13: 167.
https://pubmed.ncbi.nlm.nih.gov/8893387/
626. Garrelfs, S.F., *et al*. Lumasiran, an RNAi Therapeutic for Primary Hyperoxaluria Type 1. N Engl J Med, 2021. 384: 1216.
https://pubmed.ncbi.nlm.nih.gov/33789010/
627. Takei, K., *et al*. Oral calcium supplement decreases urinary oxalate excretion in patients with enteric hyperoxaluria. Urol Int, 1998. 61: 192.
https://pubmed.ncbi.nlm.nih.gov/9933846/
628. Hoppe, B., *et al*. Diagnostic and therapeutic approaches in patients with secondary hyperoxaluria. Front Biosci, 2003. 8: e437.
https://pubmed.ncbi.nlm.nih.gov/12957811/
629. Prezioso, D., *et al*. Dietary treatment of urinary risk factors for renal stone formation. A review of CLU Working Group. Arch Ital Urol Androl, 2015. 87: 105.
https://pubmed.ncbi.nlm.nih.gov/26150027/
630. Domrongkitchaiporn, S., *et al*. Dosage of potassium citrate in the correction of urinary abnormalities in pediatric distal renal tubular acidosis patients. Am J Kidney Dis, 2002. 39: 383.
https://pubmed.ncbi.nlm.nih.gov/11840381/
631. Maxwell A.P. Genetic renal abnormalities. Medicine, 2007. 35: 386.
https://www.medicinejournal.co.uk/article/S1357-3039(07)00109-0/fulltext
632. Dhayat, N.A., *et al*. Furosemide/Fludrocortisone Test and Clinical Parameters to Diagnose Incomplete Distal Renal Tubular Acidosis in Kidney Stone Formers. Clin J Am Soc Nephrol, 2017. 12: 1507.
https://pubmed.ncbi.nlm.nih.gov/28775126/
633. Oliveira, B., *et al*. Genetic, pathophysiological, and clinical aspects of nephrocalcinosis. Am J Physiol Renal Physiol, 2016. 311: F1243.
https://pubmed.ncbi.nlm.nih.gov/27605580/
634. Gambaro, G., *et al*. Metabolic diagnosis and medical prevention of calcium nephrolithiasis and its systemic manifestations: a consensus statement. J Nephrol, 2016. 29: 715.
https://pubmed.ncbi.nlm.nih.gov/27456839/
635. Mandel, N.S., *et al*. Urinary tract stone disease in the United States veteran population. II. Geographical analysis of variations in composition. J Urol, 1989. 142: 1516.
https://pubmed.ncbi.nlm.nih.gov/2585627/
636. Cameron, M.A., *et al*. Uric acid nephrolithiasis. Urol Clin North Am, 2007. 34: 335.
https://pubmed.ncbi.nlm.nih.gov/17678984/
637. Kim, S., *et al*. Development of Nephrolithiasis in Asymptomatic Hyperuricemia: A Cohort Study. Am J Kidney Dis, 2017. 70: 173.
https://pubmed.ncbi.nlm.nih.gov/28410765/
638. Millman, S., *et al*. Pathogenesis and clinical course of mixed calcium oxalate and uric acid nephrolithiasis. Kidney Int, 1982. 22: 366.
https://pubmed.ncbi.nlm.nih.gov/7176335/

639. Pak, C.Y., *et al*. Biochemical distinction between hyperuricosuric calcium urolithiasis and gouty diathesis. Urology, 2002. 60: 789.
https://pubmed.ncbi.nlm.nih.gov/12429297/
640. Chou, Y.H., *et al*. Clinical study of ammonium acid urate urolithiasis. Kaohsiung J Med Sci, 2012. 28: 259.
https://pubmed.ncbi.nlm.nih.gov/22531304/
641. Wagner, C.A., *et al*. Urinary pH and stone formation. J Nephrol, 2010. 23 Suppl 16: S165.
https://pubmed.ncbi.nlm.nih.gov/21170875/
642. Miano, R., *et al*. Stones and urinary tract infections. Urol Int, 2007. 79 Suppl 1: 32.
https://pubmed.ncbi.nlm.nih.gov/17726350/
643. Rodman J.S., *et al*. Diagnosis and treatment of uric acid calculi., In: Kidney Stones. Medical and Surgical Management, F.M. Coe FL, Pak CYC, Parks JH, Preminger GM., Editor. 1996, Lippincott-Raven: Philadelphia.
https://www.geneeskundeboek.nl/kidney-stones-9789351529422
644. Low, R.K., *et al*. Uric acid-related nephrolithiasis. Urol Clin North Am, 1997. 24: 135.
https://pubmed.ncbi.nlm.nih.gov/9048857/
645. Shekarriz, B., *et al*. Uric acid nephrolithiasis: current concepts and controversies. J Urol, 2002. 168: 1307.
https://pubmed.ncbi.nlm.nih.gov/12352383/
646. Wilcox, W.R., *et al*. Solubility of uric acid and monosodium urate. Med Biol Eng, 1972. 10: 522.
https://pubmed.ncbi.nlm.nih.gov/5074854/
647. Mattle, D., *et al*. Preventive treatment of nephrolithiasis with alkali citrate--a critical review. Urol Res, 2005. 33: 73.
https://pubmed.ncbi.nlm.nih.gov/15875173/
648. Marchini, G.S., *et al*. Gout, stone composition and urinary stone risk: a matched case comparative study. J Urol, 2013. 189: 1334.
https://pubmed.ncbi.nlm.nih.gov/23022002/
649. Kramer, G., *et al*. Role of bacteria in the development of kidney stones. Curr Opin Urol, 2000. 10: 35.
https://pubmed.ncbi.nlm.nih.gov/10650513/
650. Gettman, M.T., *et al*. Struvite stones: diagnosis and current treatment concepts. J Endourol, 1999. 13: 653.
https://pubmed.ncbi.nlm.nih.gov/10608517/
651. Bichler, K.H., *et al*. Urinary infection stones. Int J Antimicrob Agents, 2002. 19: 488.
https://pubmed.ncbi.nlm.nih.gov/12135839/
652. Carpentier, X., *et al*. Relationships between carbonation rate of carbapatite and morphologic characteristics of calcium phosphate stones and etiology. Urology, 2009. 73: 968.
https://pubmed.ncbi.nlm.nih.gov/19394492/
653. Thompson, R.B., *et al*. Bacteriology of infected stones. Urology, 1973. 2: 627.
https://pubmed.ncbi.nlm.nih.gov/4587909/
654. McLean, R.J., *et al*. The ecology and pathogenicity of urease-producing bacteria in the urinary tract. Crit Rev Microbiol, 1988. 16: 37.
https://pubmed.ncbi.nlm.nih.gov/3053050/
655. Wong H.Y., *et al*. Medical management and prevention of struvite stones, in Kidney Stones: Medical and Surgical Management, Coe F.M., Pak C.Y.C., Parks J.H., Preminger G.M., Editors. 1996, Lippincott-Raven: Philadelphia.
https://www.geneeskundeboek.nl/kidney-stones-9789351529422
656. Wall, I., *et al*. Long-term acidification of urine in patients treated for infected renal stones. Urol Int, 1990. 45: 336.
https://pubmed.ncbi.nlm.nih.gov/2288050/
657. Griffith, D.P., *et al*. Randomized, double-blind trial of Lithostat (acetohydroxamic acid) in the palliative treatment of infection-induced urinary calculi. Eur Urol, 1991. 20: 243.
https://pubmed.ncbi.nlm.nih.gov/1726639/
658. Williams, J.J., *et al*. A randomized double-blind study of acetohydroxamic acid in struvite nephrolithiasis. N Engl J Med, 1984. 311: 760.
https://pubmed.ncbi.nlm.nih.gov/6472365/
659. Milliner, D.S., *et al*. Urolithiasis in pediatric patients. Mayo Clin Proc, 1993. 68: 241.
https://pubmed.ncbi.nlm.nih.gov/8474265/
660. Prot-Bertoye, C., *et al*. CKD and Its Risk Factors among Patients with Cystinuria. Clin J Am Soc Nephrol : CJASN, 2015. 10: 842.
https://pubmed.ncbi.nlm.nih.gov/25717071/

661. Kum, F., *et al*. Hypertension and renal impairment in patients with cystinuria: findings from a specialist cystinuria centre. Urolithiasis, 2019. 47: 357.
https://pubmed.ncbi.nlm.nih.gov/30805669/
662. Rogers, A., *et al*. Management of cystinuria. Urol Clin North Am, 2007. 34: 347.
https://pubmed.ncbi.nlm.nih.gov/17678985/
663. Dello Strologo, L., *et al*. Comparison between SLC3A1 and SLC7A9 cystinuria patients and carriers: a need for a new classification. J Am Soc Nephrol, 2002. 13: 2547.
https://pubmed.ncbi.nlm.nih.gov/12239244/
664. Lee, W.S., *et al*. Cloning and chromosomal localization of a human kidney cDNA involved in cystine, dibasic, and neutral amino acid transport. J Clin Invest, 1993. 91: 1959.
https://pubmed.ncbi.nlm.nih.gov/8486766/
665. Knoll, T., *et al*. Cystinuria in childhood and adolescence: recommendations for diagnosis, treatment, and follow-up. Pediatr Nephrol, 2005. 20: 19.
https://pubmed.ncbi.nlm.nih.gov/15602663/
666. Finocchiaro, R., *et al*. Usefulness of cyanide-nitroprusside test in detecting incomplete recessive heterozygotes for cystinuria: a standardized dilution procedure. Urol Res, 1998. 26: 401.
https://pubmed.ncbi.nlm.nih.gov/9879820/
667. Nakagawa, Y., *et al*. Clinical use of cystine supersaturation measurements. J Urol, 2000. 164: 1481.
https://pubmed.ncbi.nlm.nih.gov/11025687/
668. Fjellstedt, E., *et al*. Cystine analyses of separate day and night urine as a basis for the management of patients with homozygous cystinuria. Urol Res, 2001. 29: 303.
https://pubmed.ncbi.nlm.nih.gov/11762791/
669. Ng, C.S., *et al*. Contemporary management of cystinuria. J Endourol, 1999. 13: 647.
https://pubmed.ncbi.nlm.nih.gov/10608516/
670. Biyani, C.S., *et al*. Cystinuria—diagnosis and management. EAU-EBU Update Series 2006. 4: 175.
https://www.sciencedirect.com/science/article/abs/pii/S1871259206000384
671. Runolfsdottir, H.L., *et al*. Urinary 2,8-dihydroxyadenine excretion in patients with adenine phosphoribosyltransferase deficiency, carriers and healthy control subjects. Mol Genet Metab, 2019. 128: 144.
https://pubmed.ncbi.nlm.nih.gov/31378568/
672. Edvardsson, V.O., *et al*. Comparison of the effect of allopurinol and febuxostat on urinary 2,8-dihydroxyadenine excretion in patients with Adenine phosphoribosyltransferase deficiency (APRTd): A clinical trial. Eur J Intern Med, 2018. 48: 75.
https://pubmed.ncbi.nlm.nih.gov/29241594/
673. Matlaga, B.R., *et al*. Drug-induced urinary calculi. Rev Urol, 2003. 5: 227.
https://pubmed.ncbi.nlm.nih.gov/16985842/
674. Beltrami, P., *et al*. The endourological treatment of renal matrix stones. Urol Int, 2014. 93: 394.
https://pubmed.ncbi.nlm.nih.gov/24969358/
675. Nakagawa, Y., *et al*. A modified cyanide-nitroprusside method for quantifying urinary cystine concentration that corrects for creatinine interference. Clin Chim Acta, 1999. 289: 57.
https://pubmed.ncbi.nlm.nih.gov/10556653/
676. Lombardo, R., *et al*. What are the benefits and harms of scheduled follow-up for patients who undergo definitive treatment of upper urinary tract stone disease? PROSPERO, 2020.
https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=205739
677. Schwartz, B.F., *et al*. The vesical calculus. Urol Clin North Am, 2000. 27: 333.
https://pubmed.ncbi.nlm.nih.gov/10778475/
678. Kum, F., *et al*. Do stones still kill? An analysis of death from stone disease 1999-2013 in England and Wales. BJU Int, 2016. 118: 140.
https://pubmed.ncbi.nlm.nih.gov/26765522/
679. Ramello, A., *et al*. Epidemiology of nephrolithiasis. J Nephrol, 2000. 13 Suppl 3: S45.
https://pubmed.ncbi.nlm.nih.gov/11132032/
680. Halstead, S.B. Epidemiology of bladder stone of children: precipitating events. Urolithiasis, 2016. 44: 101.
https://pubmed.ncbi.nlm.nih.gov/26559057/
681. Takasaki, E., *et al*. Chemical compositions of 300 lower urinary tract calculi and associated disorders in the urinary tract. Urol Int, 1995. 54: 89.
https://pubmed.ncbi.nlm.nih.gov/7538235/
682. Naqvi, S.A., *et al*. Bladder stone disease in children: clinical studies. J Pak Med Assoc, 1984. 34: 94.
https://pubmed.ncbi.nlm.nih.gov/6429380/

683. Philippou, P., *et al*. The management of bladder lithiasis in the modern era of endourology. Urology, 2012. 79: 980.
https://pubmed.ncbi.nlm.nih.gov/22119259/
684. Lal, B., *et al*. Childhood bladder stones-an endemic disease of developing countries. J Ayub Med Coll Abbottabad, 2015. 27: 17.
https://pubmed.ncbi.nlm.nih.gov/26182729/
685. Douenias, R., *et al*. Predisposing factors in bladder calculi: Review of 100 cases. Urology, 1991. 37: 240.
https://pubmed.ncbi.nlm.nih.gov/2000681/
686. Smith, J.M., *et al*. Vesical stone: the clinical features of 652 cases. Irish Med J, 1975. 68: 85.
https://pubmed.ncbi.nlm.nih.gov/1112692/
687. Millan-Rodriguez, F., *et al*. Urodynamic findings before and after noninvasive management of bladder calculi. BJU International, 2004. 93: 1267.
https://pubmed.ncbi.nlm.nih.gov/15180620/
688. Yang, X., *et al*. The value of respective urodynamic parameters for evaluating the occurrence of complications linked to benign prostatic enlargement. Int Urol Nephrol, 2014. 46: 1761.
https://pubmed.ncbi.nlm.nih.gov/24811567/
689. Childs, M.A., *et al*. Pathogenesis of bladder calculi in the presence of urinary stasis. J Urol, 2013. 189: 1347.
https://pubmed.ncbi.nlm.nih.gov/23159588/
690. Krambeck, A.E., *et al*. Experience with more than 1,000 holmium laser prostate enucleations for benign prostatic hyperplasia. J Urol, 2010. 183: 1105.
https://pubmed.ncbi.nlm.nih.gov/20092844/
691. Mebust, W.K., *et al*. Transurethral prostatectomy: immediate and postoperative complications. a cooperative study of 13 participating institutions evaluating 3,885 patients. 1989. J Urol, 2002. 167: 999.
https://pubmed.ncbi.nlm.nih.gov/11908420/
692. Chen, Y., *et al*. Bladder stone incidence in persons with spinal cord injury: Determinants and trends, 1973-1996. Urology, 2001. 58: 665.
https://pubmed.ncbi.nlm.nih.gov/11711333/
693. Hall, M.K., *et al*. Renal calculi in spinal cord-injured patient: association with reflux, bladder stones, and foley catheter drainage. Urology, 1989. 34: 126.
https://pubmed.ncbi.nlm.nih.gov/2789449/
694. DeVivo, M.J., *et al*. The risk of bladder calculi in patients with spinal cord injuries. Archives of Internal Medicine, 1985. 145: 428.
https://pubmed.ncbi.nlm.nih.gov/3977510/
695. Kohler-Ockmore, J., *et al*. Long-term catheterization of the bladder: prevalence and morbidity. Br J Urol, 1996. 77: 347.
https://pubmed.ncbi.nlm.nih.gov/8814836/
696. Bansal, A., *et al*. Prospective randomized comparison of three endoscopic modalities used in treatment of bladder stones. Urologia, 2016. 83: 87.
https://pubmed.ncbi.nlm.nih.gov/27103095/
697. Kawahara, T., *et al*. Correlation between the operation time using two different power settings of a Ho: YAG laser: laser power doesn't influence lithotripsy time. BMC Res Notes, 2013. 6: 80.
https://pubmed.ncbi.nlm.nih.gov/23510531/
698. Liu, G., *et al*. Minimally invasive percutaneous suprapubic cystolithotripsy: An effective treatment for bladder stones with urethral strictures. Int J Clin Exp Med, 2016. 9: 19907.
https://www.researchgate.net/publication/310511853
699. Soliman, N.A., *et al*. Endemic bladder calculi in children. Pediatr Nephrol, 2017. 32: 1489.
https://pubmed.ncbi.nlm.nih.gov/27848095/
700. Aurora, A.L., *et al*. Bladder stone disease of childhood. II. A clinico-pathological study. Acta Paediatr Scand, 1970. 59: 385.
https://pubmed.ncbi.nlm.nih.gov/5447682/
701. Valyasevi, A., *et al*. Studies of bladder stone disease in Thailand. VI. Urinary studies in children, 2-10 years old, resident in a hypo- and hyperendemic area. Am J Clin Nutr, 1967. 20: 1362.
https://pubmed.ncbi.nlm.nih.gov/6074673/
702. Al-Marhoon, M.S., *et al*. Comparison of Endourological and Open Cystolithotomy in the Management of Bladder Stones in Children. J Urol, 2009. 181: 2684.
https://pubmed.ncbi.nlm.nih.gov/19375100/
703. Linsenmeyer, M.A., *et al*. Accuracy of bladder stone detection using abdominal x-ray after spinal cord injury. J Spinal Cord Med , 2004. 27: 438.
https://pubmed.ncbi.nlm.nih.gov/15648797/

704. Bakin, S., *et al*. Accuracy of ultrasound versus computed tomography urogram in detecting urinary tract calculi. Med J Malaysia, 2015. 70: 238.
https://pubmed.ncbi.nlm.nih.gov/26358021/
705. Ahmed, F.O., *et al*. A comparison between transabdominal ultrasonographic and cystourethroscopy findings in adult Sudanese patients presenting with haematuria. Int Urol Nephrol, 2014. 47: 223.
https://pubmed.ncbi.nlm.nih.gov/25374263/
706. Babjuk, M., *et al*., EAU Guidelines on Non-musle-invasive Bladder Cancer (TaT1 and CIS), in European Association of Urology Guidelines 2022 edition. 2022, The European Association of Urology: Arnhem, The Netherlands.
https://uroweb.org/guideline/non-muscle-invasive-bladder-cancer/
707. Johnson, E.K., *et al*. Are stone protocol computed tomography scans mandatory for children with suspected urinary calculi? Urology, 2011. 78: 662.
https://pubmed.ncbi.nlm.nih.gov/21722946/
708. ICRP. The 2007 Recommendations of the International Commission on Radiological Protection. Publication 103, 2007. 37: 2.
https://www.icrp.org/publication.asp?id=ICRP%20Publication%20103
709. O'Connor, R.C., *et al*. Nonsurgical management of benign prostatic hyperplasia in men with bladder calculi. Urology, 2002. 60: 288.
https://pubmed.ncbi.nlm.nih.gov/12137828/
710. Lopez, J.R., *et al*. Irrigating solutions in bladder stone dissolution. Drug Intell Clin Pharm, 1987. 21: 872.
https://pubmed.ncbi.nlm.nih.gov/3678056/
711. Rattan, K.N., *et al*. Catheterless and drainless open suprapubic cystolithotomy in children: A safe procedure. Pediatric Surgery International, 2006. 22: 255.
https://pubmed.ncbi.nlm.nih.gov/16416282/
712. Ullah, S., *et al*. Comparison of open vesicolithotomy and cystolitholapaxy. Pak J Med Sci, 2007. 23: 47.
https://www.researchgate.net/publication/286561704
713. Singh, K.J., *et al*. Comparison of three different endoscopic techniques in management of bladder calculi. Indian J Urol, 2011. 27: 10.
https://pubmed.ncbi.nlm.nih.gov/21716932/
714. Ozdemir A.T, *et al*. Randomized comparison of the transurethral use of nephroscope via amplatz sheath with cystoscope in transurethral cystolithotripsy of bladder stones in male patients. J Endourol, 2012. 26: A142. [No abstract available].
715. Ener, K., *et al*. The randomized comparison of two different endoscopic techniques in the management of large bladder stones: Transurethral use of nephroscope or cystoscope? J Endourol, 2009. 23: 1151.
https://pubmed.ncbi.nlm.nih.gov/19530944/
716. Wu, J.H., *et al*. Combined usage of Ho:YAG laser with monopolar resectoscope in the treatment of bladder stone and bladder outlet obstruction. Pak J Med Sci, 2014. 30: 908.
https://pubmed.ncbi.nlm.nih.gov/25097543/
717. Halis, F., *et al*. The comparison of percutaneous and transurethral cystolithotripsy methods simultaneously performed with Transurethral Resection of Prostate in patients with BPH and bladder stone. Kuwait Med J, 2019. 51: 189.
https://acikerisim.sakarya.edu.tr/handle/20.500.12619/7152
718. Razvi, H.A., *et al*. Management of Vesical Calculi: Comparison of Lithotripsy Devices. J Endourol, 1996. 10: 559.
https://pubmed.ncbi.nlm.nih.gov/8972793/
719. Ercil, H., *et al*. Comparison of Ho:Yag laser and pneumatic lithotripsy combined with transurethral prostatectomy in high burden bladder stones with benign prostatic hyperplasia. Asian J Surg, 2016. 39: 238.
https://pubmed.ncbi.nlm.nih.gov/25937584/
720. Javanmard, B., *et al*. Surgical Management of Vesical Stones in Children: A Comparison Between Open Cystolithotomy, Percutaneous Cystolithotomy and Transurethral Cystolithotripsy With Holmium-YAG Laser. J Lasers Med Sci, 2018. 9: 183.
https://pubmed.ncbi.nlm.nih.gov/30809329/
721. Gangkak, G., *et al*. Pneumatic cystolithotripsy versus holmium:yag laser cystolithotripsy in the treatment of pediatric bladder stones: a prospective randomized study. Pediatric Surgery International, 2016. 32: 609.
https://pubmed.ncbi.nlm.nih.gov/26879752/

722. Ali, M., *et al*. Shock wave lithotripsy versus endoscopic cystolitholapaxy in the management of patients presenting with calcular acute urinary retention: a randomised controlled trial. World J Urol, 2019. 37: 879.
https://pubmed.ncbi.nlm.nih.gov/30105456/
723. Deswanto, I.A., *et al*. Management of bladder stones: The move towards non-invasive treatment. Med J Indonesia, 2017. 26: 128.
https://mji.ui.ac.id/journal/index.php/mji/article/view/1602
724. Bhatia, V., *et al*. A comparative study of cystolithotripsy and extracorporeal shock wave therapy for bladder stones. Int Urol Nephrol, 1994. 26: 27.
https://pubmed.ncbi.nlm.nih.gov/8026920/
725. Rizvi, S.A., *et al*. Management of pediatric urolithiasis in Pakistan: experience with 1,440 children. J Urol, 2003. 169: 634.
https://pubmed.ncbi.nlm.nih.gov/12544331/
726. Autorino, R., *et al*. Perioperative Outcomes of Robotic and Laparoscopic Simple Prostatectomy: A European-American Multi-institutional Analysis. Eur Urol, 2015. 68: 86.
https://pubmed.ncbi.nlm.nih.gov/25484140/
727. Matei, D.V., *et al*. Robot-assisted simple prostatectomy (RASP): does it make sense? BJU Int, 2012. 110: E972.
https://pubmed.ncbi.nlm.nih.gov/22607242/
728. Philippou, P., *et al*. Prospective comparative study of endoscopic management of bladder lithiasis: Is prostate surgery a necessary adjunct? Urology, 2011. 78: 43.
https://pubmed.ncbi.nlm.nih.gov/21296391/
729. Guo, R.Q., *et al*. Correlation of benign prostatic obstruction-related complications with clinical outcomes in patients after transurethral resection of the prostate. Kaohsiung J Med Sci, 2017. 33: 144.
https://pubmed.ncbi.nlm.nih.gov/28254117/
730. Romero-Otero, J., *et al*. Analysis of Holmium Laser Enucleation of the Prostate in a High-Volume Center: The Impact of Concomitant Holmium Laser Cystolitholapaxy. J Endourol, 2019. 33: 564.
https://pubmed.ncbi.nlm.nih.gov/30773913/
731. Tangpaitoon, T., *et al*. Does Cystolitholapaxy at the Time of Holmium Laser Enucleation of the Prostate Affect Outcomes? Urology, 2017. 99: 192.
https://pubmed.ncbi.nlm.nih.gov/27637344/
732. Romero-Otero, J., *et al*. Critical analysis of a multicentric experience with holmium laser enucleation of the prostate for benign prostatic hyperplasia: outcomes and complications of 10 years of routine clinical practice. BJU Int, 2020. 126: 177.
https://pubmed.ncbi.nlm.nih.gov/32020749/
733. Ord, J., *et al*. Bladder management and risk of bladder stone formation in spinal cord injured patients. J Urol, 2003. 170: 1734.
https://pubmed.ncbi.nlm.nih.gov/14532765/
734. Bartel, P., *et al*. Bladder stones in patients with spinal cord injury: a long-term study. Spinal Cord, 2014. 52: 295.
https://pubmed.ncbi.nlm.nih.gov/24469146/
735. Chen, H., *et al*. Can bladder irrigation reduce the morbidity of bladder stones in patients with spinal cord injury? Open J Urol, 2015. 5: 42.
https://www.researchgate.net/publication/276500148
736. Awad, S.A., *et al*. Long-term results and complications of augmentation ileocystoplasty for idiopathic urge incontinence in women. British J Urol, 1998. 81: 569.
https://pubmed.ncbi.nlm.nih.gov/9598629/
737. Blyth, B., *et al*. Lithogenic properties of enterocystoplasty. J Urol, 1992. 148: 575.
https://pubmed.ncbi.nlm.nih.gov/1640525/
738. Flood, H.D., *et al*. Long-term results and complications using augmentation cystoplasty in reconstructive urology. Neurourol Urodyn, 1995. 14: 297.
https://pubmed.ncbi.nlm.nih.gov/7581466/
739. Hayashi, Y., *et al*. Review of 86 Patients With Myelodysplasia and Neurogenic Bladder Who Underwent Sigmoidocolocystoplasty and Were Followed More Than 10 Years. J Urol, 2006. 176: 1806.
https://pubmed.ncbi.nlm.nih.gov/16945655/
740. Husmann, D.A. Long-term complications following bladder augmentations in patients with spina bifida: Bladder calculi, perforation of the augmented bladder and upper tract deterioration. Transl Androl Urol, 2016. 5: 3.
https://pubmed.ncbi.nlm.nih.gov/26904407/

741. Nurse, D.E., *et al*. Stones in enterocystoplasties. British J Urol, 1996. 77: 684.
https://pubmed.ncbi.nlm.nih.gov/8689111/
742. Shekarriz, B., *et al*. Surgical complications of bladder augmentation: Comparison between various enterocystoplasties in 133 patients. Urology, 2000. 55: 123.
https://pubmed.ncbi.nlm.nih.gov/10654908/
743. Welk, B., *et al*. Population based assessment of enterocystoplasty complications in adults. J Urol, 2012. 188: 464.
https://pubmed.ncbi.nlm.nih.gov/22704106/
744. Zhang, H., *et al*. Bladder stone formation after sigmoidocolocystoplasty: Statistical analysis of risk factors. J Pediatr Surg, 2005. 40: 407.
https://pubmed.ncbi.nlm.nih.gov/15750938/
745. Szymanski K.M., *et al*. Additional Surgeries after Bladder Augmentation in Patients with Spina Bifida in the 21st Century. J Urol, 2020. 203: 1207.
https://pubmed.ncbi.nlm.nih.gov/31951496/
746. DeFoor, W., *et al*. Bladder calculi after augmentation cystoplasty: Risk factors and prevention strategies. J Urol, 2004. 172: 1964.
https://pubmed.ncbi.nlm.nih.gov/15540766/
747. Hanna, M.K., *et al*. Challenges in salvaging urinary continence following failed bladder exstrophy repair in a developing country. J Pediatr Urol, 2017. 13: 270.
https://pubmed.ncbi.nlm.nih.gov/28262536/
748. Inouye, B.M., *et al*. Urologic complications of major genitourinary reconstruction in the exstrophy-epispadias complex. J Pediatr Urol, 2014. 10: 680.
https://pubmed.ncbi.nlm.nih.gov/25082713/
749. Lima, S.V.C., *et al*. Nonsecretory Intestinocystoplasty: A 15-Year Prospective Study of 183 Patients. J Urol, 2008. 179: 1113.
https://pubmed.ncbi.nlm.nih.gov/18206934/
750. Metcalfe, P.D., *et al*. What is the Need for Additional Bladder Surgery After Bladder Augmentation in Childhood? J Urol, 2006. 176: 1801.
https://pubmed.ncbi.nlm.nih.gov/16945653/
751. Novak, T.E., *et al*. Complications of Complex Lower Urinary Tract Reconstruction in Patients With Neurogenic Versus Nonneurogenic Bladder-Is There a Difference? J Urol, 2008. 180: 2629.
https://pubmed.ncbi.nlm.nih.gov/18951557/
752. Surer, I., *et al*. Continent urinary diversion and the exstrophy-epispadias complex. J Urol, 2003. 169: 1102.
https://pubmed.ncbi.nlm.nih.gov/12576862/
753. Palmer, L.S., *et al*. Urolithiasis in children following augmentation cystoplasty. J Urol, 1993. 150: 726.
https://pubmed.ncbi.nlm.nih.gov/8326634/
754. Kronner, K.M., *et al*. Bladder calculi in the pediatric augmented bladder. J Urol, 1998. 160: 1096.
https://pubmed.ncbi.nlm.nih.gov/9719284/
755. Silver, R.I., *et al*. Urolithiasis in the exstrophy-epispadias complex. The J Urol, 1997. 158: 1322.
https://pubmed.ncbi.nlm.nih.gov/9258206/
756. Ross, J.P.J., *et al*. Pediatric bladder augmentation - Panacea or Pandora's box? Can Urol Assoc J, 2020. 14: E251.
https://pubmed.ncbi.nlm.nih.gov/31977304/
757. Kaefer, M., *et al*. Reservoir calculi: a comparison of reservoirs constructed from stomach and other enteric segments. The J Urol, 1998. 160: 2187.
https://pubmed.ncbi.nlm.nih.gov/9817364/
758. Wang, K., *et al*. Complications after sigmoidocolocystoplasty: Review of 100 cases at one institution. J Pediatr Surg, 1999. 34: 1672.
https://pubmed.ncbi.nlm.nih.gov/10591568/
759. Wagstaff, K.E., *et al*. Blood and urine analysis in patients with intestinal bladders. British J Urol, 1991. 68: 311.
https://pubmed.ncbi.nlm.nih.gov/1913074/
760. Breda, A., *et al*. Percutaneous Cystolithotomy for Calculi in Reconstructed Bladders: Initial UCLA Experience. J Urol, 2010. 183: 1989.
https://pubmed.ncbi.nlm.nih.gov/20303534/
761. Kisku, S., *et al*. Bladder calculi in the augmented bladder: A follow-up study of 160 children and adolescents. J Pediatr Urol, 2015. 11: 66.
https://pubmed.ncbi.nlm.nih.gov/25819600/

762. Szymanski, K.M., *et al*. Cutting for stone in augmented bladders - What is the risk of recurrence and is it impacted by treatment modality? J Urol, 2014. 191: 1375.
https://pubmed.ncbi.nlm.nih.gov/24316089/
763. Schlomer, B.J., *et al*. Cumulative incidence of outcomes and urologic procedures after augmentation cystoplasty. J Pediatr Urol, 2014. 10: 1043.
https://pubmed.ncbi.nlm.nih.gov/24766857/
764. Turk, T.M., *et al*. Incidence of urolithiasis in cystectomy patients after intestinal conduit or continent urinary diversion. World J Urol, 1999. 17: 305.
https://pubmed.ncbi.nlm.nih.gov/10552149/
765. Knap, M.M., *et al*. Early and late treatment-related morbidity following radical cystectomy. Scandinavian J Urol and Nephrology, 2004. 38: 153.
https://pubmed.ncbi.nlm.nih.gov/15204405/
766. Arai, Y., *et al*. Orthotopic ileal neobladder in male patients: Functional outcomes of 66 cases. Int J Urol, 1999. 6: 388.
https://pubmed.ncbi.nlm.nih.gov/10466450/
767. Badawy, A.A., *et al*. Orthotopic diversion after cystectomy in women: A single-centre experience with a 10-year follow-up. Arab J Urol, 2011. 9: 267.
https://pubmed.ncbi.nlm.nih.gov/26579310/
768. Ji, H., *et al*. Identification and management of emptying failure in male patients with orthotopic neobladders after radical cystectomy for bladder cancer. Urology, 2010. 76: 644.
https://pubmed.ncbi.nlm.nih.gov/20573379/
769. Madbouly, K. Large orthotopic reservoir stone burden: Role of open surgery. Urol Ann, 2010. 2: 96.
https://pubmed.ncbi.nlm.nih.gov/20981195/
770. Miyake, H., *et al*. Experience with various types of orthotopic neobladder in Japanese men: Long-term follow-up. Urol Int, 2010. 84: 34.
https://pubmed.ncbi.nlm.nih.gov/20173366/
771. Moeen, A.M., *et al*. Management of neobladder complications: endoscopy comes first. Scandinavian J Urol, 2017. 51: 146.
https://pubmed.ncbi.nlm.nih.gov/28635567/
772. Simon, J., *et al*. Neobladder emptying failure in males: incidence, etiology and therapeutic options. J Urol, 2006. 176: 1468.
https://pubmed.ncbi.nlm.nih.gov/16952662/
773. Stein, J.P., *et al*. The orthotopic T pouch ileal neobladder: Experience with 209 patients. J Urol, 2004. 172: 584.
https://pubmed.ncbi.nlm.nih.gov/15247737/
774. Miyake, H., *et al*. Orthotopic sigmoid neobladder after radical cystectomy: Assessment of complications, functional outcomes and quality of life in 82 Japanese patients. BJU International, 2010. 106: 412.
https://pubmed.ncbi.nlm.nih.gov/19888974/
775. Khalil, F., *et al*. Long-term follow-up after ileocaecal continent cutaneous urinary diversion (Mainz i pouch): A retrospective study of a monocentric experience. Arab J Urol, 2015. 13: 245.
https://pubmed.ncbi.nlm.nih.gov/26609442/
776. Marien, T., *et al*. Characterization of Urolithiasis in Patients Following Lower Urinary Tract Reconstruction with Intestinal Segments. J Endourol, 2017. 31: 217.
https://pubmed.ncbi.nlm.nih.gov/27936931/
777. Davis, W.B., *et al*. Percutaneous imaging-guided access for the treatment of calculi in continent urinary reservoirs. CardioVasc Intervent Radiol, 2002. 25: 119.
https://pubmed.ncbi.nlm.nih.gov/11901429/
778. Paez, E., *et al*. Percutaneous treatment of calculi in reconstructed bladder. J Endourol, 2007. 21: 334.
https://pubmed.ncbi.nlm.nih.gov/17444782/
779. La Vecchia, C., *et al*. Genital and urinary tract diseases and bladder cancer. Cancer Res, 1991. 51: 629.
https://pubmed.ncbi.nlm.nih.gov/1985779/
780. Chung, S.-D., *et al*. A case-control study on the association between bladder cancer and prior bladder calculus. BMC cancer, 2013. 13: 117.
https://pubmed.ncbi.nlm.nih.gov/23497224/
781. Jhamb, M., *et al*. Urinary tract diseases and bladder cancer risk: a case-control study. Cancer Causes Contr, 2007. 18: 839.
https://pubmed.ncbi.nlm.nih.gov/17593531/

8. CONFLICT OF INTEREST

All members of the Urolithiasis Guidelines working panel have provided disclosure statements on all relationships that they have that might be perceived to be a potential source of a conflict of interest. This information is available on the European Association of Urology website: http://uroweb.org/guideline/urolithiasis/. This guidelines document was developed with the financial support of the European Association of Urology. No external sources of funding and support have been involved. The EAU is a non-profit organisation, and funding is limited to administrative assistance and travel and meeting expenses. No honoraria or other reimbursements have been provided.

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