REVIEW ARTICLE

Urolithiasis—an Interdisciplinary Diagnostic, Therapeutic and Secondary Preventive Challenge

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SUMMARY

Background: The prevalence of urolithiasis in Germany is 4.7%; its incidence has trebled in the last three decades. The risk of recurrence is 50–80%, depending on the type of stone, unless secondary prevention is instituted. Risk-adapted secondary prevention lowers this risk to 10–15%.

Method: This review is based on publications retrieved by a selective search in PubMed uisng the key words "urolithiasis," "urinary stones," "epidemiology," "lithogenesis," "biominerals," "risk factors," and "diagnosis, therapy, metaphylaxis." These publications were evaluated with the aid of the urolithiasis guideline of the European Association of Urology.

Results: Acute renal colic can usually be diagnosed without sophisticated equipment. Stones can be dealt with by a variety of techniques depending on their size and location, including extracorporeal shock-wave lithotripsy, ureterorenoscopy, percutaneous nephrolitholapaxy, and open surgery. Most ureteric stones of diameter up to 5 mm pass spontaneously. 75% of patients have no complications. The basic evaluation needed for secondary prevention can be carried out by any physician on an ambulatory basis. In the 25% of patients who have complications, a more extensive interdisciplinary evaluation of metabolic parameters should be performed in a clinical center for urinary stones.

Conclusion: Urolithiasis has many causes and can be treated in many different ways. An extensive metabolic work-up is often necessary for secondary prevention. The various treatment options must be considered for their suitability in each individual patient. Robust data are now available on surgical and interventional methods, but there are as yet no high-quality trials of secondary prevention. Further research should concentrate on the etiology and pathogenesis of urolithiasis.

In the year 2006 urolithiasis was second only to diseases of the prostate as the most frequent diagnosis at urological centers in Germany (1).

Urinary stones are polycrystalline concretions occurring in the urinary tract of humans and animals. Like bones and teeth, they are biominerals. While the non-pathological products of biomineralization, formed in genetically determined processes, display a high degree of biological organization, uroliths are a special case. Their formation is governed by pathoanatomical and physicochemical factors (2).

Around 97% of urinary stones are found in the kidneys and ureters (kidney stones), the remaining 3% in the urinary bladder and urethra (3). Urinary stones can range in size from micrometers to several centimeters in diameter. They frequently remain unnoticed for long periods before manifesting themselves—often very painfully—or being discovered incidentally on radiography or ultrasound *(Figure 1)*.

Urinary stones are a symptom of exo- and endogenous factors and are usually of multifactorial origin. Natural passing or surgical removal of the stone does not eliminate the cause, and many patients suffer recurrences (4).

Owing to the etiological diversity of urinary stones, many different compositions are found. Calcium oxalate (whewellite, weddellite; prevalence >80%), calcium phosphate (carbonate apatite, 5%), magnesium ammonium phosphate ("infectious stones"; struvite, 5%), and uric acid (13%) are the most commonly occurring biominerals, while cystine, ammonium urate, and brushite are rare (all ≤1%) (5, 6).

Changes in lifestyle and improvements in diagnosis have led to growing prevalence and incidence of urinary stones. In Germany, a nationwide survey showed an increase in both incidence (from 0.54% to 1.47%) and prevalence (from 4.0% to 4.7%) between 1979 and 2001 (4). Urolithiasis is thus a widespread disease. Fifty percent of patients suffer at least one recurrence, and 10 to 20% experience three or more further episodes of urolithiasis (4, 6). Prevalence of 12% has been reported in the USA (6). Affluence-related urolithiasis is also on the increase in the emerging economies, due among other reasons to highly calorific diets combined

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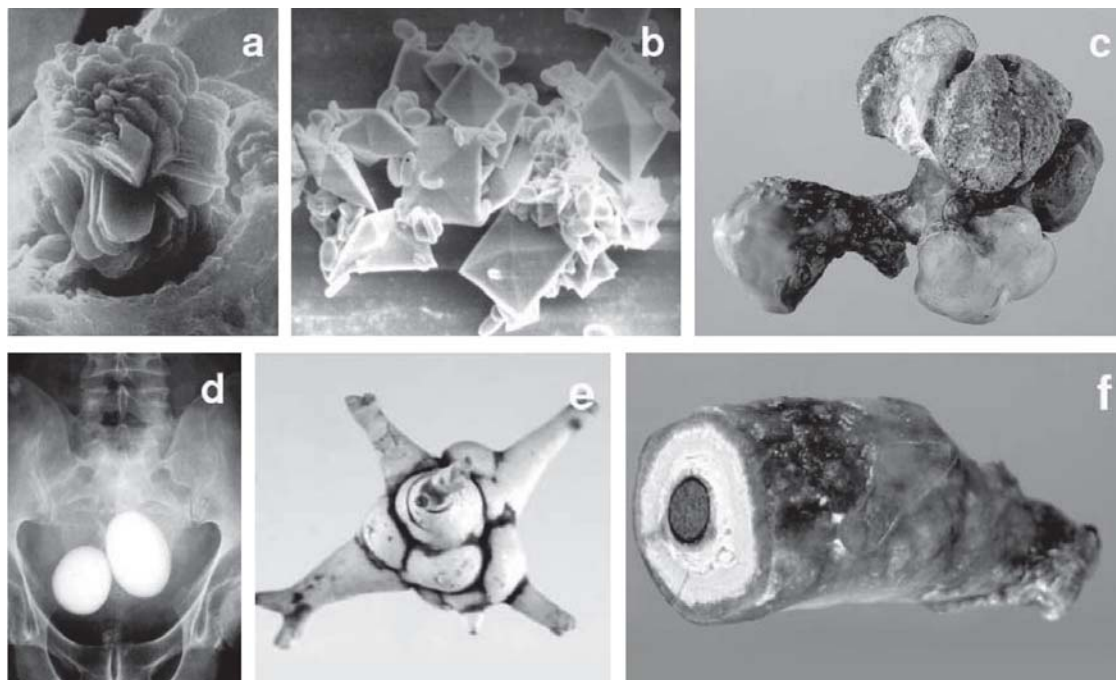
Figure 1: Starting with pathological processes in the formation of urine, mineralization can occur as high as the renal tubule (a). Crystals just a few micrometers in diameter form further downstream in the urinary tract, preferentially attaching themselves to the urothelium in sheltered niches, where—sometimes with the participation of organic cementing substances—they grow into larger aggregates (b). Under unfavorable conditions, e.g., severe metabolic disease, acute urinary tract infection, or drug-induced alteration of urinary composition, urinary stones several centimeters in diameter can form in a matter of weeks in the kidney (c), the bladder (d), or even the urethra (f). In most cases, however, the concrements (e) are flushed from the kidney into the ureter when they are just a few millimeters in diameter. They cause excruciating colicky pain and if they are too large to pass into the bladder spontaneously they have to be surgically removed.

with low levels of exercise. As early as the 12th century, Hildegard of Bingen (1098–1179) recognized the connection between rich meals, wine, and urinary stones and urged her contemporaries to modify their diets accordingly (7, 8). In the year 2000, 9.7% of German men but only 5.9% of German women in the age group 50 to 64 years had experienced an episode of urolithiasis. In the past two decades the incidence has risen predominantly between the ages of 40 and 49 years (4, 6, 9). There are differences in sex distribution and among different regions of Germany: uric acid stones are more common in the eastern and southern states, infectious stones in the east of the country (9). Calcium phosphate stones are demonstrated more often in younger patients, while uric acid stones and stones with atypical compositions are more frequent in older individuals (10). Occupation can be a risk factor: among other professions, the risk is elevated in physicians—particularly surgeons (11). Poor fluid balance is one of the factors responsible.

The essential factors accounting for variations in the prevalence of urolithiasis include dietary habits, climate, environment, ethnicity, and heredity *(Figure 2)*.

Exogenic risk factors such as nutritional patterns and lifestyles characterized by low levels of physical activity combined with high energy intake from food rich in fats, proteins, carbohydrates, and purines (13, 14) are growing in importance, as are smoking, alcohol abuse, and chronic stress (15). Increasing incidence and prevalence of urolithiasis is therefore expected, especially in Europe and the USA (7).

Acute renal colic

The most commonly occurring leading symptom is radiating colicky pain in the hypochondrium. The pain varies depending on the position of the stone in the ureter and may attain excruciating intensity (16). The worst pain is caused by high-lying concretions located in the costovertebral angle. The pain from lower-lying stones is perceived in the hypogastric region, possibly radiating as far as the genitals (16). The patients are restless and cannot find any position that relieves their pain. Accompanying vegetative reactions such as nausea and vomiting may occur. Depending on the presentation, the differential diagnoses include those of acute abdomen, i.e., pyelonephritis, diverticulitis, appendicitis, cholecystitis, and pancreatitis; however, extrauterine pregnancy and ovarian cyst with torsion, vertebrogenic symptoms, pneumonia, abdominal aortic aneurysm, and myocardial infarction also have to be taken into consideration owing to their potential consequences.

Before any diagnostic investigations are instituted, the patient suffering from colic should be given
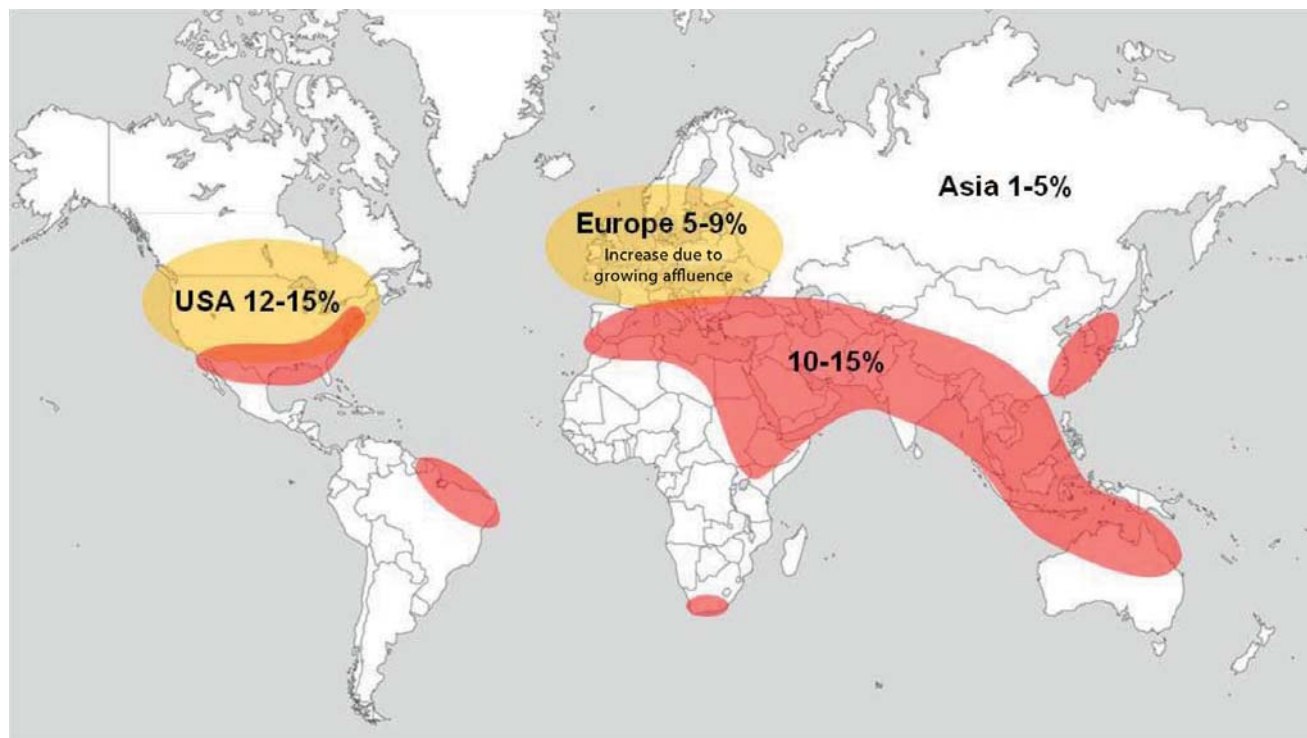
Figure 2: The so-called stone belt (red) extends all the way around the world and is characterized by urinary stone prevalence of 10 to 15%. In this zone the climatic and social conditions are conducive to stone formation. Some stones are associated with poverty, others with affluence. In Europe and the USA, there has been a sharp, almost exclusively affluence-related rise in the occurrence of calcium oxalate and uric acid stones. Climate simulations for the USA indicate that the stone belt will move northwards in the coming two decades (12).

appropriate pain-relieving medication. The options are non-steroidal antirheumatics, e.g., diclofenac and metamizole (level of evidence 1b, recommendation grade A), and opioids, e.g., tramadol (evidence level 4, recommendation grade C). These are given in combination (19–21).

Analgesia should be followed by a symptom- or differential diagnosis-oriented physical examination, which must include palpation of the renal bed and the abdomen. This should be followed by investigation of spontaneously excreted urine with a urine test strip (dipstick). Microhematuria is a strong sign of renal colic. Sonography is a valuable non-invasive diagnostic test, with sensitivity of 61 to 93% and specificity of 84 to 100%, and should follow next (6, 22). In most cases of stones in the ureter, the only sonographic finding is accumulation of urine. The stone is often not visualized directly owing to overlying intestinal gas. The triad of colicky flank pain, sonographically diagnosed ectasia of the renal calyces, and microhematuria is practically pathognomonic for ureterolithiasis. The sensitivity of microhematuria in the context of this triad is 0.95 in the acute phase (23).

If available, low-dose plain abdominal CT is the diagnostic imaging method of choice (evidence level 1a, recommendation grade A), with specificity and sensitivity of almost 99%. Stones not detected on radiography are visualized, and the density of the stone in Hounsfield units gives a first indication of its composition and helps with differential diagnosis (6, 24–26). Alternative imaging procedures are plain radiography and excretion urography. However, in acute colic the latter involves the risk of rupture of the renal calyces owing to contrast medium-induced diuresis (6).

Clinical chemistry should include electrolytes, uric acid, creatinine, C-reactive protein (CRP), complete blood count without differential, and the global parameters of coagulation (recommendation grade A) (6).

If a urinary concretion is confirmed as cause of the patient's symptoms, the treatment options depend on the location and size of the stone (6). The following are available:

- Conservative treatment
- Extracorporeal shock-wave lithotripsy (ESWL)
- Ureterorenoscopy (URS)
- Percutaneous nephrolithotomy (PCNL)
- Laparoscopy
- Open surgery

In extreme cases nephrectomy may be necessary. Laparoscopic or open surgery is usually performed in combination with the treatment of comorbidities, e.g., renal pelvic stenosis.

TABLE 1

Classification of urinary stone patients as uncomplicated on the basis of their medical history (6, 37)

Findings	Action
First episode	Cave: History of "frequent kidney pain" in childhood, but unclear origin
Age: adult	
No anatomic abnormalities	Exclusion of, for example, horseshoe kidney and outlet stenosis
Probable correlation with lifestyle	For instance, stone formation at or soon after a time of unusual stress and specific compensation reactions
Negative family history of urolithiasis	Cave: Hints of possibly undiscovered stones in family members through statements such as "There was something, but I can't quite remember..."
Single stone	Assessment with suitable imaging procedures

TABLE 2

Classification of urinary stone patients as high risk (6, 37)

Finding	Action
Age; child or adolescent	Consider assessing siblings for risk of lithogenesis
Brushite, uric acid/urate, infectious stones	Bear other accompanying minerals in mind in diagnosis and treatment
Chronic psychovegetative stress	Establish severity, perhaps with aid of validated stress-assessment systems
Single kidney	
Malformation of the urinary tract	
Disorders of gastrointestinal function	E.g., Crohn disease, ulcerative colitis, sprue, chronic pancreatitis, liver cirrhosis, small bowel resection
High recurrence rate	More than three stones in 3 years. Changes in stone type (principal and subsidiary mineral phase) or composition may indicate alterations in metabolic conditions
Hyperparathyroidism (HPT)	Five forms of HPT, primary to quinary
Nephrocalcinosis	Numerous causes, e.g., following renal tubular acidosis, primary hyperoxaluria, sarcoidosis, HPT, chronic glomerulitis
Positive family history	Consider assessing patient's children for risk of lithogenesis
Primary hyperoxaluria	Two types, autosomal-recessive hereditary disease
Renal tubular acidosis	Test by means of urinary pH curve, blood gas analysis, and ammonium chloride load test
Residual stone fragments	Possibly consider endoscopic means of stone removal, particularly when the concrement is of a type that resists disintegration by ESWL, e.g., brushite, cystine, whewellite
Cystine, 2,8-dihydroxyadenine, xanthine stones	Stone formation genetically determined; lifelong metaphylaxis is mandatory

ESWL, extracorporeal shockwave lithotripsy

Oral medicinal chemolitholysis, in which the concretion is dissolved in situ, is applicable only to uric acid stones (recommendation grade A) (6).

The German and European urolithiasis guidelines recommend the following treatment options:

Conservative stone treatment

The most frequent strategy for treatment of acute renal colic is conservative management with the aim of achieving spontaneous passage of the urinary stone (medical expulsive therapy) (evidence level 1a, recommendation grade A). Caution should be applied in the case of elevated parameters of retention or parameters of infection. Moreover, conservative treatment is not appropriate if despite adequate analgesia the patient continues to suffer pain or vegetative symptoms such as nausea and vomiting persist. Alpha-blockers promote spontaneous passage and reduce episodes of colic (evidence level 1a, recommendation grade A) (6, 20, 27–29). Rates of spontaneous passage of 71 to 98% for

distal stones ≤5 mm and 25 to 79% for stones between 6 and 10 mm are reported in the literature. Stones in the proximal ureter ≤5 mm are passed spontaneously in 29 to 98%, stones ≤10 mm in 10 to 53% of cases (30).

Other forms of conservative treatment are chemolitholysis of uric acid stones and "watchful waiting" in the case of asymptomatic kidney stones (30).

Interventional stone treatment
Renal pelvis and upper/intermediate calyces
Stones in the renal pelvis and upper/intermediate calyces can be treated by ESWL, PCNL, and flexible URS. In patients with stones ≤20 mm ESWL is the preferred method, dealing successfully with 56 to 94% of stones in the upper/intermediate calyces and 79 to 85% in the renal pelvis (recommendation grade B). For uroliths >20 mm ESWL entails the risk of leaving a trail of fragments ("steinstrasse") in the ureter and achieves lower rates of complete freedom from stones, so PCNL should be preferred (recommendation grade B) (6).

Lower calyces
For reasons of anatomy, ESWL yields lower rates of complete freedom from stones in the lower calyces. Depending on previous treatment, risk of recurrence, comorbidities, and anatomical circumstances, among other factors, mini-PCNL with a diameter of 11 to 21 Charrière is an increasingly common option for stones as small as 10 mm (recommendation grade B) (6). Flexible URS competes with ESWL for the treatment of stones up to 10 mm (6). The April 2014 revision of the EAU guidelines accords greater importance to endoscopy than in 2013. Endoscopic interventions, i.e., URS and PCNL, now seem to be just as valid as ESWL for the treatment of stones of any size in this location. Since, however, no relevant randomized studies exist, the recommendation for this upgrade of endoscopic techniques is strength B, resting on expert consensus.

Staghorn stones
Kidney stones that occupy large portions of the renal pelvis or fill at least one calyx are termed staghorn stones. The treatment options are PCNL, possibly in combination with ESWL and flexible URS, or in occasional cases nephrolithotomy. If the kidney is no longer functional, nephrectomy can be considered (6).

Proximal ureter
The preferred treatment method for stones ≤10 m in the proximal ureter is ESWL, attaining complete freedom from stones in 70 to 90% of cases (recommendation grade A) (6). If primary in-situ ESWL is not possible or is contraindicated by laboratory findings, e.g., renal failure or urinary tract infection, ureteral splinting followed by ESWL is an option. It should be noted that approximately 20% of patients have to take time off work because of the ureteral splinting alone (31).

URS is the method of choice for ureteral stones >10 mm. Recent advances in semirigid and flexible URS,

FIGURE 3
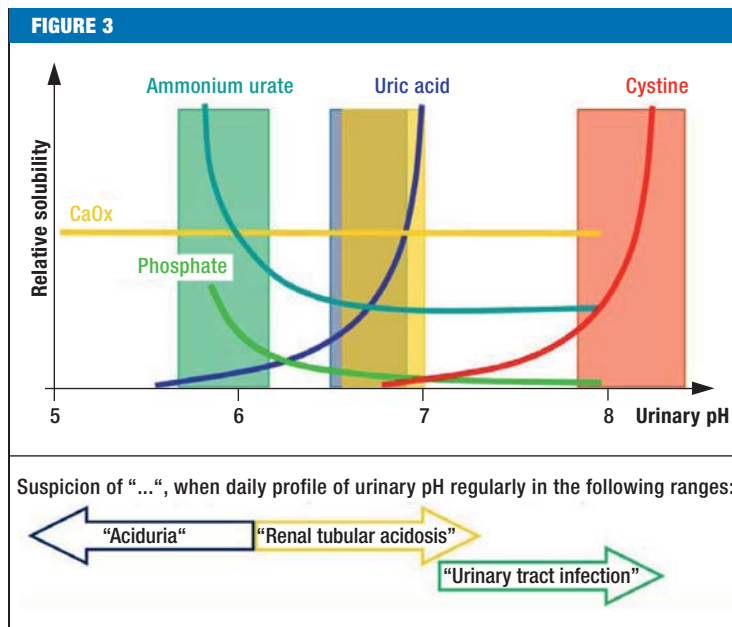
Dependence of lithogenesis on urinary pH (modified from Laube and Berg (e13).

including smaller instrument diameters and higher angles of flexion, have transformed the treatment of stones in the proximal ureter. Complete freedom from stones can now be achieved in up to 82% of cases with low complication rates (6).

Distal ureter
ESWL and endoscopy are both valid treatment options for stones ≤10 mm in the distal ureter, with complete freedom from stones achieved in 86% and 97% of cases respectively. Endoscopy is preferable for concretions >10 mm, with complete elimination of stones in 93% of patients, versus 74% for ESWL (recommendation grade A) (6).

Metaphylaxis
If successful primary treatment is to be followed by effective prevention of recurrence, the stone material must be subjected to Fourier transform infrared spectroscopy (FTIR) or X-ray diffraction (XRD) as described in the guidelines. Without analysis of the stone, no specific prophylaxis can be carried out (evidence level 2, recommendation grade A) (6, 32).

This analysis should be performed after every stone event, because the composition of consecutive stones in the same patient can change to a clinically relevant extent (evidence level 2, recommendation grade B) (6). In practice this is frequently forgotten, however, so that a long-term patient may end up receiving treatment that is no longer appropriate.

In how much detail should a stone event be investigated? Critical voices may question the point of complex postinterventional diagnostics if treatment then consists solely of the advice to increase fluid

TABLE 3

Principal substances used in medicinal prophylaxis of urinary stones (e13)

Substance	Goal	Dosage	Remarks	Stone types amenable to treatment
Alkaline citrates	– Alkalization of urine – Compensation of hypocitraturia lowers the proportion of ionized calcium in the urine. This often suffices to treat mild hypercalciuria (5–8 mmol/day). – Regulate acid – base balance in RTA and metabolic acidosis	5–12 g/day (14–36 mmol/day), children: 0.1–0.15 g/kg BW/day – Calcium oxalate metaphylaxis: to urinary pH 6.5–6.8 – Uric acid metaphylaxis: to urinary pH 6,5–6,8 – Uric acid litholysis: to urinary pH 7.0–7.2 – Cystine metaphylaxis: to urinary pH 8.0–8.5	Dose size and frequency depend on urinary pH or need to compensate acidosis. Cave: Phosphate precipitation possible in cystine metaphylaxis (→ high urinary pH)	– Calcium oxalate – Uric acid – Cystine – Non-infection-associated calcium phosphates
Allopurinol	Lowering of – Hyperuricosuria – Hyperuricemia	100–300 mg/day, children: 1–3 mg/kg BW/day	– 100 to 200 mg/day in isolated hyperuricosuria – Dose adjustment in renal insufficiency Cave: high-dose allopurinol treatment can lead to xanthinuria	– Uric acid – Calcium oxalate (only if uric acid elevated in serum or urine) – Ammonium urate – 2,8-Dihydroxyadenine
Calcium (Ca)	Lowering of enteral hyperoxaluria	160 mg corresponding to 100 mg Mg) with each meal, maximum 500 mg/day	Intake 30 min before each main meal Cave: hypercalciuria (→ testing)	Calcium oxalate
L-Methionine	Urinary acidification	600–1500 mg/day to urinary pH 5.8–6.2	Cave: contraindicated in RTA – pointless in calcium phosphates unless associated with infection (→ supporting antibiosis)	– Infectious stones – Ammonium urate – Calcium phosphate
Magnesium (Mg)	– Compensation of isolated hypomagnesiuria – Lowering of enteral hyperoxaluria – Mg (versus Ca) → non lithogenic level	200–400 mg/day, children: 6 mg/kg BW/day	Dose reduction in renal insufficiency, intake with main meals	– Calcium oxalate
Sodium carbonate	– Urinary alkalinization – Compensation of hypocitraturia, to lower proportion of ionized Ca in urine – Regulation of acid–base balance in RTA and metabolic acidosis	4.5 g/day, target urinary pH: see alkaline citrates	Dose depends on urinary pH or need to compensate acidosis	– Calcium oxalate – Uric acid – Cystine
Pyridoxine (vitamin B6)	Lowering of endogenous hyperoxaluria	Initially 5 mg/kg BW/day, maximum 20 mg/kg BW/day	If no effect, discontinue after 1 year at latest Cave: polyneuropathy	– Calcium oxalate
Thiazide (hydrochlorothiazide)	Increase in tubular Ca reabsorption in hypercalciuria (>8 mmol/day) so that renal Ca excretion goes down	12.5–50 mg/day (gradually increase dosage), children: 0.5–1 mg/kg BW/day	– Decreased glucose intolerance – Increase in serum uric acid Cave: – Tendency to hypotension – Potassium loss – (hypocitraturia)	– Calcium oxalate – Calcium phosphate
Tiopronin	Intermediate conversion of poorly soluble cystine to cysteine + cysteine–drug complex (readily soluble)	Initially 250 mg/day, maximum 2000 mg/day	Cave: – Tachyphylaxis – Proteinuria	– Cystine

RTA, renal tubular acidosis

intake. However, a renewed episode of urolithiasis may require surgical intervention, and potential complications such as acute renal failure and urosepsis must be considered, along with sometimes serious comorbidities such as chronic and terminal renal insufficiency (33). Numerous other comorbidities have been described. Rule and colleagues showed that urinary stone formation is associated with an elevated risk of myocardial infarction (34). Comparing 4564 patients with 10 860 controls, the risk was 38% higher for the former after 9 years' observation. Following adjustment for risk factors, e.g., renal insufficiency, the increase in risk was 31%. Moreover, Sun et al. described an elevated risk of urothelial cancer in urinary stone formers (35).

Postinterventional diagnosis and metaphylaxis—ideally instituted when the patient is free of stone—must be individualized and adapted to the risk constellation. The spectrum ranges from watchful waiting to interdisciplinary metabolic testing. Around 25% of stone patients belong to the high-risk group (36, 37). In an estimated 75% of cases, further stone episodes can be effectively prevented by basic metabolic diagnosis followed by general urinary stone metaphylaxis (38).

Knowledge of the patient's history and dietetic–medicinal treatment specific to stone type are, along with biochemically oriented investigation and detection of possible anatomical causes, essential for postinterventional metaphylaxis. This is true both for patients with a first stone event and for those with recurrent urolithiasis. The recurrence rate is significantly reduced by targeted treatment (10–15% vs. 50–80%) (39, 40).

The main associated factors are enzyme defects, hormonal disorders, malabsorption in the gastrointestinal tract, renal insufficiency, disorders of urodynamics, recurring urease-positive urinary tract infections, and unfavorable urinary pH. In particular, the consequences of the modern western lifestyle are risk factors for metabolic syndrome (e1–e3) and are increasingly responsible for formation of urinary stones. Overweight (body mass index [BMI] ≥ 25 kg/m^2) and obesity (BMI ≥ 30 kg/m^2) increase the risk of urinary stone formation significantly (e4, e5).

An exhaustive discussion of the pathomechanisms of biomineralization and their investigation would considerably exceed the scope of this article. Therefore the authors will confine ourselves to general orientation (36, 37).

Uncomplicated urolithiasis
Around 75% of patients with urinary stones can be categorized as uncomplicated. The basis for classifying a case of urolithiasis as complicated or uncomplicated is the patient's medical history *(Table 1)*. In simple terms, every patient who does not fulfill at least one of the criteria listed in *Table 2* is at low risk of recurrence.

Extensive metabolic diagnostics are unnecessary in uncomplicated urinary stone patients; depending on

the type of stone, however, some general measures should be carried out. This includes a comprehensive anamnesis to record potential risk factors as early as possible:

- Familial disposition
- Characteristics of metabolic syndrome, e.g., obesity, hypertension, dyslipoproteinemia, hyperglycemia.
- Mental and physical condition, e.g., mental problems such as restlessness, desensitization, disinterest and loss of motivation, and physical problems such as restricted mobility.
- Recurrent urinary tract infection
- Social and occupational factors such as partnership, unemployment, shift work, rest periods, meal breaks, frequent business trips and travel.
- Metabolic disorders, e.g. renal reabsorption and transport disorders: renal leak (calcium, phosphate); aciduria (urinary pH permanently <6.0; associated for instance with metabolic syndrome and favored by excessive consumption of animal protein); cystinuria; enteral hyperabsorption of lithogenic substances (e.g., calcium, oxalate); hormonal disorders (e.g., of parathormone and cortisol levels); elevated vitamin D3 level; enzyme deficiencies.
- Urodynamic anomalies: The history may include flank pain after increased fluid intake, a feeling of incomplete emptying of the bladder, flank pain on micturition, recurring urinary tract infections, or incidental sonographic detection of urinary transport disorders, possibly even in the uterus during routine antenatal examination. If any of these are found, further investigation for urodynamic anomalies is indicated.
- Causative comorbidities, for example Crohn disease, short bowel syndrome, cystic fibrosis, osteoporosis, or catabolic metabolism, e.g., owing to tumor, pancreatic, or hepatic disease.

Screening for severe metabolic disorders is mandatory in high-risk patients, and because there is no clear dividing line between low and high risk in clinical practice, we also recommend it for low-risk patients:

- For at least 3 days the patient should keep a nutritional diary, recording all food and drink consumed with details of amount and time. This readily reveals any special features of the diet, e.g., whether the person is omnivorous, carnivorous, vegetarian, or vegan.
- A sample of urine should be taken from every micturition for a week under normal conditions and tested for pH. The resulting urinary pH profile can exclude, for example, renal tubular acidosis (RTA). Patients with RTA have a tubular disorder of proton excretion or bicarbonate resorption, leading to metabolic acidosis. The urinary pH is typically permanently <5.8. Furthermore, weekday-related or lifestyle-associated fluctuations in pH (e.g., workdays versus weekend) can be detected.

- Blood testing (standard blood count plus calcium, creatinine, and uric acid) (recommendation grade A); careful determination of parathormone in all patients barring completely uncomplicated cases (e6).
- Investigation of at least one 24-h urine sample (e7): volume, pH *(Figure 3)*, sodium, potassium, calcium, magnesium, ammonia, chloride, oxalate, citrate, phosphate, uric acid, and creatinine (recommendation grade A). If any signs of infection are noted, a sample of urine must be prepared for bacterial culture (14).
- Calculation of empirical risk indices for urinary stone formation from the above-mentioned urinary parameters (e8, e9) and/or additional determination of the crystallization risk using the BONN Risk Index (BRI) (e10–e12). This enables more detailed evaluation of both the risk profile and the disease course.

If the basic diagnostic measures confirm a stone patient's classification as uncomplicated, this metabolic screening need not be carried out. General urinary stone metaphylaxis with regular follow-ups is sufficient (6, 36, 37, 39).

Complicated urolithiasis
Around 25% of urinary stone patients are categorized as complicated. These patients, classified by the guidelines as high risk, show at least one of the characteristics listed in *Table 2*.

The basic investigation as carried out in uncomplicated patients is followed by the extended metabolic screening described above. This involves complex interdisciplinary diagnostics that should be performed at a specialized center. When an individual patient's urinary stone formation has been fully characterized and medicinal treatment is required, various agents are available. The most important of them are listed in *Table 3*.

Conclusion
Urolithiasis is already widespread and is growing in prevalence. A wide range of options are available for surgical treatment. The EAU guidelines provide information on surgery and metaphylaxis. A useful German-language overview of the differential diagnoses is provided by a practical chart, oriented on the urinary stone guidelines, in which details of pathogenesis, metabolic diagnosis, and metaphylaxis are summarized (e13).

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KEY MESSAGES

- Urolithiasis is a symptom of many renal, endocrine, intestinal, and occasionally even malignant diseases. Stone formation is often triggered and influenced by external risk factors.

- The choice and success of methods to remove urinary stones depend on the site, size, and composition of the concretion and on any comorbidities.

- There are various types of urinary stone, some of which form under mutually exclusive physicochemical conditions. Analysis of uroliths is therefore mandatory.

- Targeted anamnesis permits every patient to be categorized as high or low risk. The subsequent diagnostic and therapeutic measures depend on this classification.

- Individualized, risk-adapted metaphylaxis reduces the risk of recurrence from ca. 50% to around 15%.

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