

REVIEW

Management of urinary stones by experts in stone disease (ESD 2026)

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Summary

The prevalence of urinary stones range between 1 and 14% in different countries around the world. Men account for approximately 67% of cases, but the gender gap is narrowing over time. A study conducted in the Russian Federation showed that 22.2% of subjects interviewed with a questionnaire reported a history of urolithiasis. Stone formation begins with the urinary crystallization of less soluble solutes contained in urine (calcium oxalate and/or calcium phosphate, uric acid, struvite, and cystine), which often depends on urinary pH values. The most common calcium oxalate stones can grow on calcium phosphate plaques (Randall's plaque) that emerge on the surface of the papilla or on calcium oxalate plugs that form in the collecting ducts due to excessive concentrations of calcium or oxalate. Randall's plaques form due to a proinflammatory process initiated by local macrophages with activation of fibroblasts, matrix modeling, and interstitial calcium phosphate deposition. The inhibito-

ry effect of crystallization and crystal aggregation was studied in vitro demonstrating a reduction in the nucleation inhibition index and in aggregation inhibition index in renal stone formers compared to healthy controls (2.15% vs 6.15% and 34.15% vs 62.15%, respectively). Urolithiasis is a cluster of metabolic phenotypes interacting through urinary supersaturation. The metabolic work-up consists in the identification of high-risk patients requiring full metabolic profiling by basic metabolic panel, two 24-hour urine collections, stone analysis (when available), and software assessment of Relative Supersaturation (RSS) for calcium oxalate, calcium phosphate and uric acid. The endpoint of therapy is to reduce RSS not just to achieve "normal" lab values. The most active agents used for the prevention of calcium oxalate stones are phytate, potassium citrate, and magnesium. Phytate stands as the most potent inhibitor of both calcium oxalate and calcium phosphate crystallization exerting its therapeutic effect without modifying uri-

nary pH. It is the ideal inhibitor of calcium oxalate crystallization, particularly in cases of severe hypercalciuria, because it does not increase the risk of secondary calcium phosphate crystallization. Potassium citrate has a weaker direct inhibitory potential at the concentrations achieved in standard clinical practice and tends to increase urinary pH, posing a risk of inducing calcium phosphate precipitation. Magnesium does not affect urinary pH, but its inhibitory effect of calcium oxalate crystallization is negligible at conventional clinical doses. However, it reduces intestinal oxalate absorption and subsequent urinary oxalate excretion, making it a potentially useful agent for stone prevention. The combination of phytate and magnesium represents an ideal synergistic strategy for the prevention of recurrent calcium oxalate urolithiasis. Medical expulsive therapy with alpha-blockers is generally well tolerated, although may be associated with hypotension, dizziness, and ejaculatory dysfunction. Nonsteroidal anti-inflammatory drugs should be used with caution due to the risks of renal impairment and gastrointestinal complications, whereas opioids should be reserved for selected cases because of their potential for adverse gastrointestinal effects and dependency. A proactive strategy focused on prevention, combining lifestyle changes, metabolic assessment, and targeted treatment, offers significant clinical, economic, and ecological advantages. A comprehensive approaches, including increased hydration, dietary modifications, metabolic evaluation and pharmacological treatment can reduce recurrence rates by 60-80% and lower overall costs per each event avoided. However, long-term compliance remains challenging, particularly when lifestyle recommendations are perceived as restrictive or complex. To address this challenge, mobile health applications are emerging as effective tools to support lifestyle modifications and enhance patient engagement. Currently the surgical treatment of urinary stones is based on percutaneous nephrolithotomy (PCNL) and retrograde intrarenal surgery (RIRS). Recent advancements in PCNL are miniaturized tracts, suction integrated lithotripsy, enhanced ultrasound guided access, and optimized endoscopic combined intrarenal surgery (ECIRS) techniques. Current evidence increasingly favors supine PCNL as a highly efficient technique, demonstrating shorter operative times and lower complication rates compared to the prone approach. Prone positioning remains a valuable option for specific clinical scenarios requiring complex puncture strategies or multitract access. Modified or intermediate positions remain a valuable tactical option in challenging scenarios, such as significant anatomical deformities or developmental renal anomalies, where a personalized approach is required. True supine position without bolster or tilting can be facilitated by using the "Dixit Line" as anatomical landmark for safe planning of calyceal puncture. RIRS innovations are related to new lasers for stone dusting, suction integrated access sheaths, slim digital flexible ureteroscopes, and pressure controlled systems that improve efficiency and safety. The ultra-slim HU-30S ureteroscope enables retrograde intrarenal surgery (RIRS) without pre-stenting and is easily manipulated through a 9 or 10 F sheath providing greater infusion space and preventing pressure and temperature rise during laser lithotripsy. Flexible and navigable suction ureteral access sheaths (FANS) represent one of the most significant recent innovations in RIRS combining active suction with distal flexibility and navigability to the target calyx and allowing direct evacuation of stone dust and fragments during laser lithotripsy. RIRS is also a safe and effective solution in

selected anomalous kidneys such as horseshoe kidneys, ectopic pelvic kidneys, calyceal diverticular stones and selected nephrocalcinosis cases for reducing intraductal pressure or removing obstructive stones. PCNL remains the first option for staghorn calculi with stone-free rates ranging from 70% to 90% although it has come limitations as bleeding, sepsis, and the possible need for multiple access tracts or staged procedures. Mini-PCNL provides stone-free rates comparable to standard PCNL, with reduced hemoglobin drop and transfusion risk, although operative time may be longer. The integration of suction systems and the simultaneous retrograde approach can potentially shorten operative time and perioperative morbidity as well as increasing the stone-free rates. Retrograde intrarenal surgery as monotherapy has a limited role for staghorn stones. Complications of surgical treatment of kidney stones are related to increased intrarenal pressure and temperature resulting from irrigation and laser use, and the risk of intraoperative bleeding. All the minimally invasive treatments for stone removal still imply a risk of kidney damage, with mechanisms and extent varying across methods. ESWL can cause self-limiting kidney injury by mechanical and vascular trauma although repeated high-energy shocks could cause fibrosis and hypertension. Major damage (hematoma, steinstrasse) is rare. RIRS carries risks of kidney damage from high intrarenal pressure (above 40 cm of water) and heat from high-power lasers whereas PCNL is the more invasive procedure being associated with risks of trauma, vascular injury and infectious complications. Anticoagulant and antiplatelet therapy increase the risk of bleeding complications during stone removal procedures. The risk is moderate to high for extracorporeal shock wave lithotripsy (ESWL), low to moderate for ureteroscopy, and high for percutaneous nephrolithotomy. Ureteroscopy should be preferred whenever possible in patients on anticoagulant and/or antiplatelet therapy. ESWL requires discontinuing therapeutic low-molecular-weight heparin and careful evaluation of risk-benefit for aspirin. Percutaneous nephrolithotomy requires discontinuation of warfarin, direct oral anticoagulants, and clopidogrel. Routine bridging is no longer recommended for most patients. Stent encrustation represents a clinically significant adverse event, leading to complex management scenarios and increased healthcare costs. Prolonged indwelling time is commonly associated with encrustation with rates up to 75% at > 12 weeks. Minimizing indwelling time, following strict follow-up protocols, optimizing stent material selection, and modifying the urinary environment are essential to prevent stent encrustation. Administration of L-methionine, phytate and theobromine was associated with 95% lower odds of stent encrustation compared to a placebo group. Urinary acidification is also a non-antibiotic strategy for managing recurrent urinary tract infections in women. L-methionine can reduce urinary pH to around 5.0 creating a hostile environment for bacterial survival. It also enhances the effectiveness of certain antibiotics as fosfomycin which increases its activity at lower pH levels. Phytate can be used in conjunction to acidification to reduce bacterial proliferation and persistence in the urinary tract by multiple antimicrobial effects.

KEY WORDS: : Urinary calculi; Citrate; Phytate; Theobromine; L-methionine; Shock wave lithotripsy; Retrograde intrarenal lithotripsy; Percutaneous nephrolithotomy; Flexible and Navigable Suction ureteral access sheath.

Submitted ; Accepted

INTRODUCTION

(Athanasios Papatsoris - Tariq Karmouni - Soufiane Mellas)

The *Experts in Stone Disease* (ESD) Conference has grown to a well-established international forum where experts from around the globe, gather to exchange scientific knowledge and share their experience and innovations in the aetiology, management and prevention of urolithiasis. The 8th Edition of the ESD Conference was held in Marrakesh on 9-10 April 2026 under the chairmanship of Prof. Thanos Papatsoris and Dr. Soufiane Mellas in conjunction with the *National Association Marocaine d'Urologie* (AMU) congress. This collaboration reflects our continued commitment to strengthening regional and international collaborations and fostering engagement of scientists of different specialities dedicated to stone disease. In this paper we accumulate multidisciplinary presentations on the latest developments in surgical techniques, technological advantages, metabolic evaluations and basic science on urolithiasis.

EPIDEMIOLOGY

Innovations in stone surgery in North Africa

(Adil Mellouki)

Urolithiasis represents a significant global clinical and economic burden, with a prevalence of approximately 11%. In North Africa, urologists frequently encounter high stone burdens and complex renal anatomies resulting from delayed patient presentations. To address these challenges, the field is undergoing a rapid transition from conventional methods to highly specialized, minimally invasive technologies. A primary innovation is the *Thulium Fiber Laser* (TFL), which outperforms the Holmium:YAG standard by offering four times the ablation speed and minimal retropulsion. TFL produces a fine "dusting" effect, contributing to single-stage stone-free rates (SFR) of 92-96% and a 20-30% reduction in operative time. This efficacy is maximized when synergized with navigable suction *ureteral access sheaths* (UAS), which facilitate continuous fragment evacuation and lower intrarenal pressure, resulting in SFRs exceeding 95% and a significant reduction in post-operative infections. Miniaturization remains a cornerstone of progress. Techniques such as Mini-PCNL (14-20 Fr) and Micro-PCNL (≤ 4.8 Fr) have revolutionized percutaneous access by reducing hospital stays and minimizing hemorrhagic morbidity. Furthermore, the adoption of single-use flexible ureteroscopes ensures optimal infection control and eliminates high maintenance costs associated with reusable equipment. The digital transformation is led by robotic-assisted platforms and *Artificial Intelligence* (AI). Robotics provide superior precision and ergonomics compared to conventional retrograde intrarenal surgery. Concurrently, *Mixed Reality* (MR) and 3D modeling are transforming preoperative planning, allowing for accurate needle guidance during PCNL to avoid adjacent organ injury. AI is now a transformative force used for automated stone identification on imaging and predicting stone composition. Finally, the shift toward precision medicine involves analyzing the renal urobiome to under-

stand stone formation pathways. However, the sources emphasize that technological innovation is incomplete without strategic health policies to ensure equity and accessibility. Addressing financial toxicity and regional disparities is essential for the sustainable implementation of these advancements in Africa.

Novel epidemiological data & environmental risk factors

(Refaat Abusamra)

Global Epidemiology and Incidence: urolithiasis (kidney stone disease) is a prevalent urological condition worldwide, with prevalence rates varying from about 1% in parts of Asia to 13% in North America. Demographics (*Gender, Age, Ethnicity*): men account for approximately 67% of cases, but the gender gap is narrowing (male-to-female ratio decreasing from 2.2:1 in 1990 to 2.04:1 in 2021); prevalence increases with age, from 5% in ages 20-39 to nearly 20% in men > 80 years; ethnic disparities exist: Non-Hispanic Whites have the highest prevalence (~12%), Hispanics (~9%), and Asian/Black populations lower (~4-6%), this being influenced by environmental and lifestyle factors. Dietary and fluid factors: diet and hydration are major modifiable risk factors: high sodium, excessive animal protein, and sugary beverages increase risk; sufficient fluid intake, fruits, vegetables, and appropriate calcium intake are protective; tea and coffee consumption are linked to lower kidney stone risk. Comorbid Conditions: strong associations exist between urolithiasis and metabolic syndrome components: obesity, hypertension, diabetes, and *chronic kidney disease* (CKD). Environmental and Occupational Risk: occupations with exposure to high heat or chemicals raise risk. Climatic Influence: warm, humid climates provoke fluid and increased stone risk; tropical/subtropical regions ("stone belts") exhibit 5-10% prevalence; temperate/cold regions show 1-5%. Fluid Intake and Hydration: high fluid intake (water > 2500 mL/day and urine output ~2 L/day) reduces nephrolithiasis risk. However, increased consumption of sugar-sweetened soft drinks correlates with a 23-33% increased stone risk; artificially sweetened drinks show borderline risk. Tea and coffee, both sources of theobromine and caffeine may reduce stone risk

Results of opportunistic screening of urolithiasis

(Mikhail Yu Prosyannikov)

Urolithiasis is a pressing issue in modern medicine, occupying a leading position among kidney diseases. Over the past decade, the prevalence of urolithiasis has been steadily increasing, averaging up to 10%. Meanwhile, the number of hospitalizations for urolithiasis ranges 30-60%. To determine the prevalence of urolithiasis among outpatients in the Chuvash Republic (Russian Federation) as part of opportunistic screening for urolithiasis. Opportunistic screening of 4,473 patients who consulted general practitioners without specific complaints of urological diseases was conducted from 2021 to 2022 at the Emergency Hospital No. 1 in Cheboksary (Chuvash Republic). Study participants completed a questionnaire about urolithiasis. Ultrasound were used for the detection of stones by twinkling artifacts. In questionable cases, in the presence of dilated renal pelvis a CT scan of the abdominal organs was performed. Statistical data pro-

cessing was performed using Statistics 10.0 and Microsoft Excel. Of the 4,473 patients identified, 994 (22.2%) had a history of urolithiasis. Among men, urolithiasis diagnosed 1.5 times more often: 13.32% and 8.88%, respectively. Fifty-two respondents (1.2%) reported previous surgery for urinary stones. The age groups most affected are those between 40-44 years (8.16%), 25-29 years, and 50-54 years (6.67%). The average duration of illness was 3.4 ± 0.1 years, with longer duration observed in the 25-29 age groups (4.4 ± 0.67 years) and in the 70 years and older (4.24 ± 0.24 years). The lowest incidence was among individuals aged 45-49 (duration 2.61 ± 0.27 years). Among 3,473 patients without a history of urolithiasis who underwent opportunistic urolithiasis screening, 11.7% of patients had urinary stones: 13.3% in men and 8.6% in women. The average age was 56.79 ± 0.84 and 60.81 ± 1.42 years, respectively. The male to female ratio was 1.5:1.0. The average size of the stones detected was 6.28 ± 0.22 mm. The most common location was the lower group of calyces. No statistical difference was found between kidney stone size in men (6.30 ± 0.20 mm) and women (6.30 ± 0.65 mm) ($p > 0.05$). The prevalence of kidney stones among outpatients in the Chuvash Republic (Russian Federation), determined through opportunistic screening for consolidation, was 11.7%: 13.2% in men and 8.6% in women.

PATHOGENESIS

Crystallization & stone formation

(Alberto Trinchieri)

The first step in the formation of urinary stones is the crystallization and crystalline aggregation of less soluble urinary components (1). Numerous types of crystals can form in the urine, which can aggregate and lead to the formation of various types of kidney stones.

Crystallization depends on the excretion of urinary solutes, the urinary volume, and the solubility constant of the corresponding salt. In many cases, solubility is influenced by urinary pH, which is a measure of the concentration of hydrogen ions (Table 1).

Crystallization is influenced by the presence of crystallization inhibitors which can be low molecular weight molecules (magnesium, citrate, pyrophosphate, phytate) or macromolecules (proteins or glycosaminoglycans). The effect of the inhibitors can be thermodynamic, through the formation of more soluble complexes than those forming urinary crystals, or thermokinetic, through interference with crystalline growth and aggregation. Urinary saturation can be calculated with specific software that considers all the ionic components that influence the formation of calcium oxalate and calcium phosphate crystals, or uric acid. Saturation is expressed as a beta value, which, when > 1 , indicates a condition of supersaturation relative to a specific salt. Above this level, crystal formation should begin, although this occurs at a higher threshold in the urine due to the effect of crystallization inhibitors. Crystalline formation, growth, and aggregation represent the first step towards stone formation, although this only occurs under other conditions. Indeed, urinary flow tends to eliminate crystalline aggregates that are not large enough.

Stone formation can occur through the mechanism of "fixed" particles or through that of "free" particles (2). In the first case, calcium oxalate crystals attach and grow on small de-epithelialized areas of the renal papilla consisting of calcium phosphate crystals that have a typical whitish spot appearance (Randall's plaque). In the second case, a large quantity of crystals accumulates in a collecting duct that is obstructed by a yellowish plug that protrudes from the collecting duct orifice onto the papilla (plug) where the crystalline growth process begins. The formation of free stones in the lumen of the renal cavities

Table 1.
Risk factors for urinary crystallization.

Stone type	Favorite pH	Key Notes
Calcium oxalate	Any pH	pH effect minimal/controversial High urinary concentrations of calcium and/or oxalate Role of low-molecular weight inhibitors (magnesium, citrate, pyrophosphate, phytate)
Apatite	> 6.0	High urinary concentrations of calcium and phosphate
Brushite	$> 6.2-6.5$	Role of inhibitors (e.g. phytate)
Struvite	> 7.2	High urinary concentrations of ammonium, magnesium and phosphate Infection stones; require urease producing bacteria. Role of acidifying agents (e.g.L-methionine)
Uric acid	< 5.2	Normal/high urinary concentrations of uric acid Role of alkalinizing agents (citrate, bicarbonate) Role of inhibitors (theobromine)
Sodium urate	$6.0-7.5$	High urinary concentrations of urate Role of inhibitors (theobromine)
Ammonium urate		High urinary concentrations of urate and ammonium 1) ureolysis by bacterial urease 2) cereal-based diet deficient in inorganic phosphate depletes urine of a major buffer resulting in up-regulation of ammoniogenesis Role of inhibitors (theobromine)
Cystine	< 7.0	High urinary concentration of cystine

is exceptional and can be attributed to very severe cases of cystinuria or infectious stones. Plugs occur in extreme metabolic alterations such as primary or enteric hyperoxaluria or severe forms of hypercalciuria (HPT, RTA, etc.). Randall's plaques can also occur in conditions of mild or moderate metabolic alterations, being the origin of the commonest type of stones that are composed of calcium oxalate monohydrate. The plaques form because the presence of oxalate or calcium phosphate crystals in the renal tubules acts as a danger signal on epithelial tubular cells and local macrophages (3). The M1 macrophage population produces a proinflammatory response with interleukin production, while the M2 population has a protective effect by eliminating the crystals through phagocytosis. If the M1 population is prevalent, a process of sterile local inflammation begins, leading to the formation of Randall's plaque with a mechanism similar to that of atherogenic plaque formation through the activation of fibroblasts, matrix modeling and interstitial calcium phosphate deposition on the papilla to form the typical whitish spots on which calcium oxalate stones grow.

Assessing the anticrystallization activity of urine in the prevention of stone formation

(Mikhail Yu Prosyannikov)

Crystallization is the underlying process of stone formation. This process is currently largely unstudied in the context of urolithiasis metaphylaxis, as simple diagnostic methods and tools for widespread use are lacking. Several hypotheses exist, including the assessment of crystallization phases (nucleation, crystal growth, and/or aggregation). We comprehensively determined the *anti-crystallization properties* of urine (ACP) in patients with calcium oxalate stones and healthy individuals. Urine collected from 30 healthy individuals and 60 patients with calcium oxalate urolithiasis were analyzed using a developed urine anti-crystallization activity analyzer based on turbidimetry. To initiate the crystal formation reaction, CaCl_2 + diluted native urine + $\text{K}_2\text{C}_2\text{O}$ placed in a quartz cuvette in the analyzer and mixed. The device was equipped with stirring and thermoregulation to prevent crystal precipitation and maintain body temperature at 37°C. An aqueous solution (without urine) is used as control. The analyzer software converted the received signals into *millivolts* (mV), and a curve corresponding to the crystallization phases was plotted. Based on the obtained data, the following control points were determined: point 0 (t0) - reaction start, point 1 (t1) - maximum solution turbidity and maximum nucleation level, point 2 (t2) - ten-minute interval from point t2, characterizing the development of aggregation. Based on these parameters, the nucleation and aggregation inhibition indices were calculated using the following formulas:

Nucleation inhibition index (NII) =

$$(1 - ((t0_u - t1_u) / (t0_w - t1_w))) * 100,$$

Aggregation inhibition index (AI) =

$$(1 - ((t2_u - t1_u) / (t2_w - t1_w))) * 100,$$

(u = in the presence of the test urine, and w = in the absence of urine.

The values of points 1 and 2 (in mV) differed in healthy individuals from those in patients. This indicates that inhibitory activity of nucleation was reduced in patients

compared to healthy individuals: the *nucleation inhibition index* (NII) was 2.15%, while in healthy individuals it was 6.15% ($p < 0.05$). The aggregation process was more pronounced in patients, corresponding to a higher *aggregation inhibition index* (AI): 34.15% versus 62.15% in healthy individuals ($p < 0.05$). Urine anti-crystallization activity in patients with calcium oxalate stones is reduced compared to healthy individuals. Further research need to implement a method for determining urinary anti-crystallization activity.

PREVENTION

Optimal metabolic work-up in urolithiasis

(Kyriaki Stamatelou)

Urolithiasis is a complex, multifactorial systemic disorder rather than simply a surgical disease (4).

As a chronic metabolic disorder urolithiasis is linked to systemic diseases:

1. Patients with urolithiasis are at higher risk for Chronic Kidney Disease and for cardiovascular diseases. Entity is described as the "Cardio-Renal Link" (5-6)
2. Hypercalciuria is linked to bone resorption and osteoporosis indicating the presence of a Bone-Kidney Axis and possible involvement of the FGF23-PTH axis (7).
3. Hyperoxaluria is linked to disorders of the gut microbiome and the oxalate-degrading bacteria (8).

Urolithiasis is a cluster of metabolic phenotypes interacting through urinary supersaturation. Without metabolic work-up it presents recurrence rates up to 50% in 5yrs (9) while with targeted therapy the recurrence rate can be reduced up to 70% (10).

The "Optimal Metabolic Work-up" is not just a generic check-up but a complete attempt to formulate a quantitative risk and phenotype-driven patient individualized model. The model is based on urinary supersaturation (RSS), points at the diagnosis of the disorder and ultimately guides further therapy by reducing the urinary *supersaturation* (SS) and by modifying the promoters and inhibitors of crystallization appropriately (11).

Therefore, the most effective strategy for therapy is: Phenotype Identification followed by a targeted intervention and followed by a repeated metabolic assessment.

The 1st step of the metabolic work-up is the Risk Stratification and the identification of high-risk patients who require full metabolic profiling (12):

- Patients with comorbidities such as: Diabetes, Metabolic Syndrome, Obesity, CKD, GI diseases (Crohn's, IBD, bariatric surgery), Urinary Tract Infections, Hyperparathyroidism, Renal Tubular Acidosis, Spinal cord injury, Neurogenic bladder, Polycystic kidney disease, Cystinuria, Primary hyperoxaluria, Sarcoidosis.
- Patients with a solitary kidney or renal tract abnormalities or recurrent, bilateral or infectious stones.
- Patients with early onset of urolithiasis (< 40 yrs) or positive family history.
- Patients with specific environmental, geographic, occupational or racial risk factors.

The 2nd step consists of a basic metabolic panel plus cal-

Table 2.
24-hour Urine Collection (Core of “metabolic workout”).

Disorder	Clinical Role
Low Volume	Decreases dilution / increases SS
Hypercalciuria	Promotes lithogenesis / increases SS
Hyperoxaluria	Promotes lithogenesis / increases SS
Hypocitraturia	Inhibitor deficit
Hyperuricosuria	Promotes lithogenesis
High Urine Sodium	Driver of calciuria / Promoter
Urinary pH	Determines uric acid / CaP risk
Low Urine Magnesium	Inhibitor deficit
Low Urine Creatinine	CHECK Collection validity and GFR
Albuminuria	CHECK renal function and CKD

Minimum: 2 collections (to reduce variability), Creatinine = Collection validity.
Optional: Magnesium, Ammonium, Sulfate.

cium, albumin, phosphate, magnesium, uric acid, creatinine (eGFR), bicarbonate, PTH, Vitamin D, a urinalysis, a urine culture and two 24 hours urine collections for volume, creatinine, calcium, citrate, oxalate, uric acid, sodium, potassium, magnesium, chloride, sulfate, phosphate, ammonium and cystine (if cystine stone is confirmed or suspected) (Table 2). Stone analysis is essential when available (9).

The 3rd step is the assessment of *Relative Supersaturation* (RSS) of CaOx, CaP and Uric acid (risk of crystalluria and recurrent stone formation), using any one of the following: SUPERSAT, EQUIL 2, EQUIL 93, SEQUIL, JESS, Tiselius Risk Index, Robertson Risk Factor Analysis “RRFA”, BONN-Risk Index (13).

These are the 5 major metabolic phenotypes that will guide urolithiasis treatment:

1. Hypercalciuria: > 200 mg/day (women) or 250 mg/day (men) or 4 mg/kg/day.
2. Hyperoxaluria: > 40 mg/day (≈ 0.45 mmol/day).
3. Hypocitraturia: < 500 mg/day (optimal > 600-700 mg/day)
4. Low urine Volume: < 2.5 L/day
5. Urinary pH: < 5.5 (persistent)

Follow-up is repetition of 24h urine collection at 3-6 months after intervention and then annually in order to adjust therapy dynamically based on SS changes.

The true end-point in terms of therapy is to reduce RSS not just to achieve “normal” lab values.

Prevention of calcium oxalate stones

(Jordi Guimerà)

Calcium oxalate nephrolithiasis can be broadly classified into two distinct phenotypes: *calcium oxalate monohydrate* (COM) and *calcium oxalate dihydrate* (COD). COM calculi are not typically driven by severe urinary metabolic abnormalities. Instead, their development is commonly associated with a persistently acidic urinary pH (< 5.5), low urine volume, mild hypocitraturia, and occasionally, mild hyperoxaluria (14). Conversely, COD calculi are closely linked to a primary, significant metabolic disorder: hypercalciuria. It is crucial to highlight that the coex-

istence of hypercalciuria and an elevated urinary pH (> 6.0) severely increases the risk of calcium phosphate crystallization, specifically hydroxyapatite and brushite (15).

The therapeutic active ingredients evaluated for the prevention of calcium oxalate lithiasis are phytate, potassium citrate, and magnesium. *Phytate*: Among the three agents, phytate stands out as the most potent inhibitor of both calcium oxalate and calcium phosphate crystallization. At the skeletal level, it acts similarly to bisphosphonates by effectively inhibiting bone resorption. Furthermore, it exerts its therapeutic effect without modifying urinary pH (16). These unique features render phytate the ideal inhibitor for calcium oxalate urolithiasis, particularly in cases of severe hypercalciuria, as it safely mitigates stone formation without increasing the risk of secondary calcium phosphate crystallization. *Potassium Citrate*: Potassium citrate also functions as an inhibitor of calcium oxalate lithiasis, although its direct inhibitory potential remains weak at the concentrations achieved in standard clinical practice. It operates primarily as a calcium chelator within the urine and elevates urinary pH. Therefore, its use should be strictly reserved for patients presenting with hypercalciuria and a urinary pH below 5.3. Administering it at higher baseline pH levels poses a significant risk of inducing calcium phosphate precipitation (17). *Magnesium*: Magnesium contributes to the inhibition of calcium oxalate crystallization, though this effect is negligible at conventional clinical doses. It functions fundamentally as an oxalate chelator and does not alter urinary pH. Given these distinct pharmacological properties, the combination of phytate and magnesium represents an ideal synergistic strategy for the prevention of recurrent calcium oxalate urolithiasis (17).

Cost analysis of stone prevention

(Guzmán Ordaz Jurado)

Kidney stone management represents a significant financial burden worldwide, with the global urolithiasis treatment market projected to reach approximately \$4.5 billion in 2026. Surgical treatments such as *shockwave lithotripsy* (ESWL), *retrograde intrarenal surgery* (RIRS), and *PCNL percutaneous nephrolithotomy* (PCNL) vary widely in cost depending on the country, ranging from relatively affordable options in countries like India and Turkey to significantly higher expenses in the United States and Western Europe. Beyond direct medical expenses, kidney stones generate considerable “invisible” costs. These include productivity loss (estimated at \$5,500-\$8,000 per patient), prolonged recovery times, caregiver burden, medication expenses, and the impact of stent-related symptoms. Recurrence is a major issue, with approximately 50% of patients experiencing another episode within five years, effectively doubling long-term costs for both patients and healthcare systems. In addition to economic costs, there is a growing concern regarding the sustainability of healthcare systems. Many modern urological procedures rely on single-use devices, including laser fibers, scopes, and disposable instruments. The increasing dependence on these materials contributes to the depletion of natural resources required for their production and generates significant medical

waste. This raises important environmental and ethical questions about the long-term viability of current treatment models, especially when many of these interventions could be avoided through effective prevention strategies. Multiple studies consistently demonstrate that prevention strategies are highly cost-effective (18, 19). Simple interventions such as increased hydration and dietary modifications can cost less than \$100 per year while potentially saving over \$1,000 annually if recurrence is reduced. More comprehensive approaches, including metabolic evaluation and pharmacological treatment, show even greater benefits, reducing recurrence rates by 60-80% and lowering overall costs per event avoided. Economic models suggest that investing in prevention yields substantial returns: for every \$1 spent on metabolic evaluation and medical management, healthcare systems can save \$10-\$15 in avoided surgical costs over a five-year period.

A recent economic study showed that a preventive strategy combining Lit-Control® pH Meter plus targeted oral pharmacological treatment may save €757 per patient per year and become dominant in front of other strategies.

In conclusion, the current reactive approach to kidney stone disease is economically inefficient and environmentally unsustainable. A proactive strategy focused on prevention – combining lifestyle changes, metabolic assessment, and targeted treatment – offers significant clinical, economic, and ecological advantages.

Side effects of urolithiasis treatment regimens and Medications

(Julian Vesper)

Urolithiasis is a common urological disease with high recurrence rates and a substantial impact on patient quality of life. Modern management therefore focuses not only on acute stone removal but also on long-term prevention strategies aimed at reducing recurrence and minimizing the need for invasive surgical interventions. Conservative and pharmacological treatment approaches play a central role in this framework, although their benefits must always be balanced against potential adverse effects and patient adherence. Conservative management, including increased fluid intake, dietary modification, and metabolic evaluation, represents the cornerstone of recurrence prevention in many stone formers. Adequate hydration and individualized nutritional counseling have been shown to significantly decrease stone recurrence and may reduce the necessity for repeated surgical procedures. However, long-term compliance remains challenging, particularly when lifestyle recommendations are perceived as restrictive or complex. Excessive fluid intake may additionally contribute to electrolyte imbalance or aggravation of lower urinary tract symptoms (LUTS) in susceptible individuals. Medical expulsive therapy (MET), particularly with alpha-blockers such as tamsulosin, may facilitate spontaneous passage of small distal ureteral stones and thereby help avoid surgical intervention. While generally well tolerated, treatment may be associated with hypotension, dizziness, and ejaculatory dysfunction. Furthermore, the off-label character of MET in urolithiasis patients should be clearly communicated. Pain management remains essential in acute stone

episodes and directly influences patient comfort and treatment success. *Nonsteroidal anti-inflammatory drugs* (NSAIDs) are widely used due to their analgesic and anti-inflammatory properties, although renal impairment and gastrointestinal complications must be considered, especially in vulnerable patients. Opioids should be reserved for selected cases because of their potential for adverse gastrointestinal effects and dependency. In recurrent stone disease, individualized pharmacological prevention strategies are increasingly important. Potassium citrate, thiazide diuretics, and other metabolic therapies can substantially reduce recurrence risk when tailored to specific metabolic abnormalities identified during evaluation. Nevertheless, these therapies may also cause gastrointestinal discomfort, electrolyte disturbances, or reduced adherence during long-term treatment. Overall, successful urolithiasis management requires a patient-specific and preventive approach integrating metabolic work-up, conservative treatment, and selective intervention. Such strategies not only improve long-term outcomes but may also reduce morbidity associated with recurrent invasive stone procedures.

PCNL

Prone versus supine positioning in percutaneous nephrolithotomy; current evidence and practical considerations

(Vigen A. Malkhasyan, Sergey O. Sukhikh, Dmitry Yu. Pushkar)
Percutaneous nephrolithotomy (PCNL) remains the gold standard treatment for large and complex renal stones. Since the first nephrostomy procedures described by Fernström & Johansson in 1976, patient positioning during PCNL has evolved substantially (20). Although prone positioning dominated the early era of PCNL, the introduction of the supine approach by Valdivia initiated ongoing debate regarding the optimal surgical position (21, 22). Today, numerous modifications of both techniques exist; however, the core discussion still centers on prone versus supine PCNL (23).

Current evidence suggests that both approaches provide comparable surgical efficacy (24-32). Early meta-analyses reported slightly higher *stone-free rates* (SFR) in prone PCNL, yet more recent large-scale studies involving nearly 12,000 patients demonstrated no significant difference between the two techniques (33) (Table 1). Thus, contemporary data support equivalent effectiveness regarding stone clearance. Technical considerations, however, differ substantially. While prone positioning is traditionally thought to offer a superior acoustic window for ultrasound-guided access and multitract procedures, empirical evidence is scarce and remains controversial (34-36). Conversely, supine PCNL offers superior access to the upper calyx due to more favorable anatomical angles for rigid nephroscope manipulation (37). Nevertheless, supine positioning is associated with longer access tracts, increased renal mobility, and partial collapse of the collecting system caused by gravity-assisted drainage, potentially complicating intrarenal navigation (38). Safety outcomes increasingly favor the supine approach. Recent meta-analyses report lower rates of major complications,

Table 3.

Summary of meta-analyses comparing outcomes of prone versus supine percutaneous nephrolithotomy (PCNL).

	SFR (Stone-free rate)	Fever	Complications	Bleeding	Hospital stay	Operative time
24 Liu et al., 2010	No difference	No difference	No difference	No difference	-	Prone
25 Wu et al., 2011	No difference	-	-	No difference	No difference	Prone
25 Zhang et al., 2014	Prone	-	No difference	-	No difference	Prone
27 Yuan et al., 2016	Prone	-	No difference	Prone	No difference	Prone
28 Li et al., 2019	No difference	Prone	No difference	No difference	No difference	Prone
29 Birowo et al., 2020	Prone	-	Prone	-	No difference	No difference
30 Keller et al., 2021	No difference	Prone	No difference	No difference	No difference	Prone
31 Falahatkar et al., 2016	No difference	Prone	No difference	Prone	No difference	No difference
32 Lachkar et al., 2025	No difference	-	Supine	No difference	No difference	Supine

* Specified positions (Prone/Supine) indicate a statistically significant advantage or higher rate for that specific parameter. "No difference" indicates no statistically significant clinical disparity between the two positions.

bleeding, fever, sepsis, and adjacent organ injury in supine PCNL (32). This advantage may partially result from anatomical differences, as the retrorenal colon is significantly less common in the supine position (39). In addition, supine PCNL provides several anesthetic benefits, including easier airway access, improved venous return, and simplified cardiopulmonary resuscitation access. Although prone ventilation has demonstrated benefits in acute respiratory failure, studies comparing prone and supine PCNL have shown no clinically significant differences in blood gases or hemodynamic parameters (40, 41). Another important consideration is occupational safety. Radiation exposure to the surgeon's eyes and extremities appears approximately 1.3-1.5 times lower during supine PCNL. Furthermore, operative time is consistently shorter in supine procedures, mainly due to elimination of patient repositioning and improved operating room workflow efficiency (30, 32, 42).

Regarding operative time and length of stay, Meta-analytical data suggest the supine position reduces operative time by 12-14 minutes compared to the prone position, while the length of hospital stay remains comparable between both techniques (33) (Table 1).

In summary, current evidence increasingly favors supine PCNL as a highly efficient technique, demonstrating shorter operative times and lower complication rates compared to the prone approach. While the supine position offers clear ergonomic and safety advantages, prone positioning remains a valuable option for specific clinical scenarios requiring complex puncture strategies or multi-tract access. Ultimately, both techniques are clinically relevant, and the choice of approach should be individualized, guided by both the patient's anatomy and the surgeon's expertise. Furthermore, modified or intermediate positions remain a valuable tactical option in challenging scenarios, such as significant anatomical deformities or developmental renal anomalies, where a personalized approach is required to ensure safe and effective access.

True supine PCNL

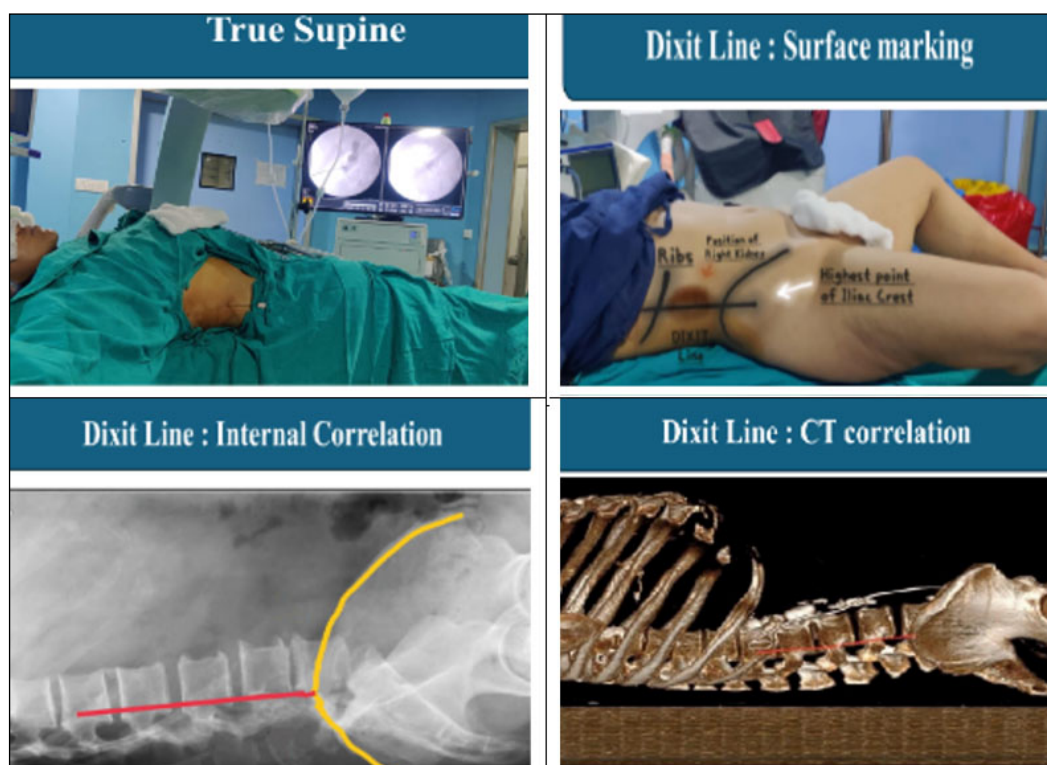
(Vimal Kumar Dixit)

Percutaneous nephrolithotomy (PCNL) performed in the supine position offers several advantages; however, obtaining a safe and accurate calyceal puncture remains

challenging. Conventionally used *posterior axillary line* (PAL) may vary with body habitus due to marking from skin fold and it gives no guidance for needle track, potentially affecting puncture accuracy and increasing the risk of adjacent organ injury.

We aimed to describe and evaluate simple unmodified "True Supine position" and a novel anatomical landmark the "Dixit Line" for planning calyceal puncture and safeguarding surrounding organs during true supine PCNL. According to this technique, the patient lies in True Supine Position without bolster or tilting or lithotomy. The Dixit Line is drawn from the highest point of the iliac crest perpendicularly towards the rib cage. In the supine position, this line appears horizontal relative to the operating table and serves as a fixed landmark for renal access (Figure 1).

Preoperative *computed tomography* (CT) axial images are utilized to reproduce the anticipated needle trajectory by drawing a horizontal line from the posterior border of the lumbar vertebrae (as Dixit line runs parallel to the line drawn at posterior border of lumbar vertebrae) This allows prediction of the access tract and identification of any intervening organs before surgery. During the procedure, ureteric catheterization is done with nephroscope in straight leg position (or temporary frog leg for female). After retrograde pyelography and calyceal selection, the needle puncture is performed on Dixit Line and advanced horizontally toward the target calyx. Occasional cranial tilt of C arm is used for needle entry angle in case horizontal advancement does not puncture calyx. The Dixit Line aligns with the majority of renal calyces and provides a reproducible access route based on a fixed bony landmark (Highest point of iliac crest). Correlation with CT imaging facilitates precise preoperative planning and enables assessment of potential organ transgression along the intended tract. The technique simplifies calyceal puncture and enhances procedural safety by minimizing the risk of surrounding organ injury. In conclusion, the Dixit Line represents a simple, reproducible, and anatomically reliable landmark for renal access in true supine PCNL. Integration of this landmark with preoperative CT-based trajectory planning may improve puncture accuracy and safety across a wide range of patients, stone burdens, and renal anomalies.

**Figure 1.**

The Dixit line: from the highest point of the iliac crest perpendicularly towards the rib cage. In the supine position, this line appears horizontal relative to the operating table and serves as a fixed landmark for renal access.

RETROGRADE INTRARENAL SURGERY (RIRS)

Slim 6.3 disposable flexible ureteroscopy (fURS)

(Athanasios Papatsoris)

Flexible ureteroscopy (fURS) has been increasingly used as the first-line treatment for urolithiasis as well as diagnosis of other upper tract pathologies (4, 43, 44). Single-use (disposable) fURS has enormously progressed because new slimmer scopes provide increasing efficacy (45). Until a few years ago, the slimmest diameter of commercially-available models was the 7.5 Fr (e.g. the EndoView HU-30S by HugelMed). The last years, HugelMed was the first to launch the 6.3 Fr fURS in the global market (46). The ultra-slim HU-30S enables *retrograde intrarenal surgery* (RIRS) without pre-stenting (avoidance of another procedure) and insertion of ureteral access sheaths (avoidance of ureteral injury) which results in less costs. In case a ureteral access sheath is used the HU-30S is easily manipulated through a slim 9 or 10 Fr sheath and more stone expelling space is achieved between the ureter and the outer surface of the scope. Likewise, it provides greater infusion space. This will prevent pressure and temperature rise during laser (i.e. Thulium) lithotripsy, relief renal pressure and improve the stone-clearance rate and reduce the likelihood of post op steinstrasse. The HU-30M weights only 300g; thus it effectively prevents operator's fatigue during long operations. Its standard parameters, include an adjustable angle knob as well as a 285° bending range in both directions, a 1080P optimization algorithm and a passive bending function. A unique characteristic of the HU-30M is that the scope is produced with either 3 or 9 o'clock working channel for right and left kidney, respectively. There is no time limit in working with the HU-

30M; therefore, the term disposable is preferred over the term single use. Once the safety/working wire is inserted into the kidney the scope can be easily advanced over it just as we advance a 6 Fr JJ stent. In conclusion, the 6.3 F scope could be the first option for fURS and we are looking forward to testing slimmer scopes.

RIRS in anomalous kidneys

(Petrisor Geavlete, Cristian Mares, Bogdan Geavlete)

Retrograde intrarenal surgery (RIRS) has progressively become an essential option for the management of renal stones in anomalous kidneys. Horseshoe kidney, ectopic pelvic kidney, malrotated kidney, duplex collecting system, calyceal diverticulum, and medullary sponge kidney represent complex anatomical scenarios in which conventional stone treatment may be limited by abnormal calyceal orientation, impaired drainage, ureteropelvic junction abnormalities, difficult access, and increased risk of residual fragments. Contemporary flexible ureteroscopy has significantly changed this field. Multicenter data show that stones in anomalous kidneys are usually of moderate size, with a mean diameter around 14 mm, and that ureteral access sheath use, pre-stenting, disposable scopes, and Holmium laser lithotripsy are frequently used. However, success is not determined only by technology, but also by careful preoperative imaging, precise understanding of intrarenal anatomy, and staged treatment when necessary. Our personal experience, accumulated over three decades in a high-volume academic stone center at "Saint John" Clinical Emergency Hospital in Bucharest, confirms that RIRS may provide a safe and effective solution in selected anomalous kidneys. In horseshoe kidneys, ideal cases are those without significant UPJ stenosis, severe hydronephrosis,

or unfavorable infundibulocalyceal anatomy. In ectopic pelvic kidneys, staged flexible ureteroscopy may be necessary, with progressive improvement of stone-free status after repeated sessions. Calyceal diverticular stones and selected nephrocalcinosis cases may also benefit from flexible ureteroscopy and laser treatment, particularly when symptom relief depends on reducing intraductal pressure or removing obstructive stones. The current evolution of RIRS is driven by single-use flexible ureteroscopes, improved lasers, modern access sheaths, suction-assisted systems, direct in-scope suction, and intelligent intrarenal pressure control. In anomalous kidneys, these innovations are especially relevant because complete dust evacuation, reduced intrarenal pressure, shorter procedures, fewer residual fragments, and lower reintervention rates are crucial objectives. Therefore, RIRS should be regarded not merely as a stone-fragmentation technique, but as an integrated anatomical, technological, and strategic approach to complex renal stone disease.

Flexible and navigable suction sheaths in retrograde intrarenal surgery: improving stone clearance and procedural efficiency

(Julian Vesper)

The introduction of flexible and navigable suction ureteral access sheaths (FANS) represents one of the most significant recent innovations in RIRS. While conventional ureteral access sheaths facilitate repeated access and irrigation, FANS technology aims to address persistent limitations of RIRS, including inefficient fragment evacuation, prolonged operative times, elevated intrarenal pressures, and residual stone fragments (47). The principal advantage of FANS lies in its ability to combine active suction with distal flexibility and navigability. Unlike traditional suction ureteral access sheaths, the flexible distal segment can be advanced closer to the target calyx, allowing direct evacuation of stone dust and fragments during laser lithotripsy. This approach shifts RIRS away from the traditional paradigm of fragmentation followed by basket extraction toward a more efficient strategy based on dusting or fragmentation with simultaneous suction-mediated clearance, minimizing the need for auxiliary retrieval devices and streamlining stone removal (48). Emerging clinical evidence suggests that FANS may significantly improve procedural outcomes. Recent systematic reviews and meta-analyses have demonstrated higher stone-free rates and lower perioperative complication rates compared with conventional ureteral access sheaths. Notably, these benefits appear particularly relevant in patients with larger stone burdens, where fragment extraction often represents the main limitation of standard RIRS. Furthermore, several studies have reported a marked reduction in basket utilization, reflecting the ability of FANS systems to achieve continuous fragment clearance throughout the procedure (44). Beyond fragment management, FANS may improve intrarenal pressure control. By creating a low-pressure outflow pathway adjacent to the ureteroscope, these systems facilitate irrigation while limiting pressure accumulation within the collecting system. Recent experimental and clinical investigations have demonstrated favorable intrarenal pressure profiles during FANS-assisted RIRS, supporting their potential role in reducing pyelovenous

backflow and infectious complications (49). The clinical applicability of FANS has also expanded beyond routine renal stones. Multicenter studies have reported encouraging outcomes in bilateral same-session RIRS and in the treatment of larger renal calculi, suggesting that suction-assisted flexible ureteroscopy may increasingly challenge traditional size thresholds that previously favored percutaneous approaches (50). Despite these promising results, the current evidence remains largely derived from retrospective series and early multicenter experiences. Heterogeneity in device design, suction settings, laser technologies, and definitions of stone-free status limits direct comparison between studies. Nevertheless, available data consistently indicate that FANS improves stone clearance efficiency while maintaining a favorable safety profile. As technology continues to evolve, flexible and navigable suction systems may become a key component of next-generation RIRS, particularly for complex stones where effective fragment evacuation remains the critical determinant of procedural success.

STAGHORN STONES

Staghorn stones: PCNL, ECIRS or RIRS?

(Salim Lachkar)

Staghorn calculi are among the most challenging entities in endourology because they combine high stone burden, complex intrarenal distribution, infection-driven growth, and a risk of renal function loss. They are better defined by anatomical extension within the pyelocalyceal system than by maximal diameter alone, and are classified as partial or complete according to calyceal involvement (51, 52). Their pathogenesis is frequently infection-related or mixed: urease-producing bacteria induce urinary alkalization, promote struvite and carapatite crystallization, sustain biofilm formation, and maintain a persistent infectious reservoir (53, 54). Management should aim not only at lithotripsy, but at complete stone clearance, infection eradication, renal function preservation, and reduced morbidity. Preoperative CT assessment is essential. Conventional scores such as Guy's Stone Score, S.T.O.N.E., CROES, and S-ReSC are useful in general PCNL populations, but remain imperfect for staghorn calculi. Beyond stone size, morphometric parameters integrating stone volume and spatial distribution are required. The Mishra model, based on total stone volume and unfavorable calyx stone percentile volume, represents the first staghorn-specific morphometric classification and may help predict multiple tracts or staged procedures (55, 56). Percutaneous nephrolithotomy remains the first-line backbone for staghorn calculi, with stone-free rates commonly ranging from 70% to 90%. Its main limitations are bleeding, sepsis, prolonged operative time, and the possible need for multiple access tracts or staged procedures (57) (Table 4). Mini-PCNL appears to provide stone-free rates comparable to standard PCNL, with reduced hemoglobin drop and transfusion risk, although operative time may be longer (58). Retrograde intrarenal surgery as monotherapy has a limited role. It is feasible and safe in selected patients, but usually requires multiple sessions and is less efficient for large branched stones.

Table 4.
Procedures for staghorn stones.

Technique	Reported stone-free rate	Preferred role	Main limitation
PCNL	70-90%	First-line for most staghorn calculi	Bleeding, sepsis, multiple tracts or staged procedures
ECIRS	> 80% up to 82-97% in selected series	Complex anatomy, complete or multicalyceal staghorn calculi	Requires expertise, equipment, and team coordination
RIRS	33-93%, usually session-dependent	High-risk patients, residual fragments, staged strategy	Lower efficiency as monotherapy, multiple sessions

It should be reserved for high-risk patients, anticoagulated patients, morbid obesity, unfavorable percutaneous access, refusal of PCNL, or as a staged option. Its strongest role is adjunctive, particularly for residual fragments after PCNL or within ECIRS (51, 59-61). ECIRS combines simultaneous antegrade PCNL and retrograde RIRS, usually in a modified supine position. It improves calyceal visualization, facilitates puncture and guidewire placement, reaches blind calyces, reduces multiple tracts, and enables final ureteroscopic inspection (62). Comparative studies suggest improved one-step stone-free rates and fewer complications or ancillary procedures compared with PCNL alone (63-65). Technique selection should be anatomy-guided: complex calyceal anatomy, complete or multicalyceal stones favor ECIRS, whereas RIRS remains selective, staged, or adjunctive (55).

Mini-PCNL for patients harboring Staghorn calculi (Oriol Angerri, Francesco Di Bello)

Percutaneous nephrolithotomy (PCNL) is recommended as the first-line treatment for renal stones larger than 2 cm (66). Within this context, patients with staghorn calculi represent a particularly challenging subgroup, given their increased susceptibility to infections and the risk of progressive renal function deterioration (51, 67). It should be acknowledged that staghorn calculi are most commonly made of struvite, caused by urease-producing bacterial infections (68). However, mixed compositions are also common and may include calcium phosphate or calcium oxalate components (68). All these aspects result in important clinical implications, as infection-related stones tend to grow rapidly, recur frequently, and require complete removal to prevent persistent infection and regrowth (68). Recent technological advancements, as the miniaturization of instruments and the increasing use of *endoscopic combined intrarenal surgery* (ECIRS), have introduced a new paradigm in stone management (69). These innovations combine smaller percutaneous tracts with a simultaneous retrograde approach that can potentially shorten operative time and perioperative morbidity (67, 70, 71). Furthermore, the integration of suction systems during endoscopic surgery may hold an additional advantage in reducing the infectious complications as well as increasing at most the *stone-free rates* (SFR) (72). Indeed, the suction devices may improve the visibility and the evacuation of residual fragments, and, consequently, reduce intrarenal pressure. Lower intrarenal pressure may, thus, decrease the risk of pyelovenous and pyelolymphatic backflow, lowering the odds of infectious complications and sepsis (72). Despite technical advancements and improvements in the endourological armamentarium, the management of staghorn calculi may

require staged or ancillary procedures to achieve optimal SFR (51). This aspect should be clearly addressed during preoperative patient counselling, sensitizing the patients to the likelihood of multiple interventions. As such, in a “salvage setting”, flexible ureteroscopy following percutaneous procedures plays a pivotal role, contributing to achieving an overall SFRs of 90% in selected series (51). Furthermore, the concept of SFR in this patient population remains heterogeneous and not fully standardized, as it is influenced by imaging modality, timing of SFR assessment, and the clinical relevance of residual fragments (73). However, a more nuanced definition of SFR for staghorn calculi is therefore needed. The presence of residual fragments may not represent an optimal outcome for patients with a single stone in a normal urinary anatomy. Conversely, it may be acceptable in cases of staghorn calculi if a substantial reduction in stone burden is achieved. Thus, this concept remains underestimated in current guidelines and literature. Consequently, further evidence is needed. Future studies should focus on large prospective cohorts, standardized outcome definitions, improved volumetric assessment of stone burden, and clearer clinical contextualization of SFR to better guide decision-making and optimize patient care.

Difficult stone surgery (Murtadha Almusafir)

Difficult renal stones are stones that are large, complex, or anatomically challenging including staghorn calculi, multiple stones, solitary kidney with stones, and forgotten DJ stents. They often require advanced surgical techniques. The major challenges are complex renal anatomy, limited access to calyces, bleeding risk, associated infection, and patient comorbidities. Special issues are renal stones in transplanted kidney, complex renal stone associated with skeletal abnormalities, stones in urinary diversion or ileal ureter. In particular, treatment of renal stone in transplanted kidney requires a difficult selection of the appropriate technique for stone removal, although management principles are similar to those applied for other single renal units. Additional factors such as transplant function, coagulative status and anatomical obstacles due to the iliac position of the organ directly influence the surgical strategy. Preoperative evaluation for difficult stones should include non-contrast CT scan to evaluate stone size, density, and location and renal anatomy and anomalies; urine culture and infection control; assessment of coagulation profile. The main surgical options are PCNL, mini-PCNL, RIRS, *endoscopic combined intrarenal surgery* (ECIRS) and open or laparoscopic surgery (rare). PCNL is the preferred option for staghorn stones: multiple tracts or use of flexible nephroscope may be required. It could

be performed in both supine or prone position. ECIRS is a combination of PCNL and RIRS that Improve stone clearance and reduce the need for multiple tracts being useful in cases with complex anatomy.

Intraoperative complications are bleeding, pelvic perforation, infection and sepsis, adjacent organ injury. Postoperative care includes monitoring hemoglobin, checking for fever/sepsis, imaging for residual stones, and nephrostomy management. In conclusion, difficult renal stones require individualized planning. PCNL remains the gold standard although ECIRS improves outcomes in complex cases. Multidisciplinary approach is important.

COMPLICATIONS

Monitoring intrarenal pressure & temperature

(Dimitri Staïos)

Intrarenal pressure (IRP), intrarenal temperature (IRT), suction and irrigation are the four elements of quadrifecta of retrograde intrarenal surgery (RIRS) (74) and IRP, IRT alongside with access represent the crucial aspects for complications in RIRS (71). So intraoperative monitoring of intrarenal pressure and temperature during retrograde intrarenal surgery (RIRS) is critical to minimizing complications such as pain, backflow, tissue damage, and sepsis. Elevated IRP, exceeding physiological ranges (< 15 mmHg or < 20 cmH₂O), can lead to adverse outcomes including fornix rupture, urinoma, hemorrhage, and systemic infection (75). Strategies to regulate IRP, such as the use of ureteral access sheaths (UAS) and suction technology, have demonstrated effectiveness in maintaining stable pressures and also in reducing thermal injury. Monitoring systems incorporating digital sensors allow real-time pressure assessment, although control remains limited (76). Temperature management is equally essential; tissue damage occurs at temperatures above 43°C, and is especially associated to the combination of temperature level and exposure time of tissue. A temperature of 43°C > 120 min has a high probability of tissue damage and when the temperature increases the time limit is even shorter (77). During laser lithotripsy, particularly holmium YAG and TFL lasers generate significant heat that can cause urothelial injury if not properly managed (78, 79). Techniques such as optimizing irrigation flow (> 40 mL/min), using chilled or room temperature irrigation fluids, and intermittent laser activation can mitigate thermal risks (80). The integration of flow and temperature control facilitates safer procedures by reducing the incidence of complications such as fever, SIRS, and long-term tissue damage. In conclusion, comprehensive intraoperative management of IRP and temperature, supported by advanced monitoring and irrigation strategies, is

pivotal to improve patient safety and surgical outcomes in RIRS.

Anticoagulants and antiplatelet agents in endourological stone surgery

(Juan Antonio Mainez Rodríguez)

Anticoagulants (warfarin, direct oral anticoagulants (DOACs), heparins) inhibit the coagulation cascade and are primarily used to prevent venous thrombosis and embolism in atrial fibrillation or mechanical heart valves. Antiplatelet agents (aspirin, clopidogrel, ticagrelor) inhibit platelet function and are indicated for coronary artery disease, stents, and cardiovascular prevention (81, 82) (Table 5).

General Principles of Perioperative Management:

The 2022 American College of Chest Physicians guidelines recommend against routine bridging with heparin in most patients, as it increases bleeding without reducing thromboembolic events (82). For DOACs, due to their short half-life, simple discontinuation 1-2 days before low-to-moderate bleeding risk procedures and 2 days before high-risk procedures is sufficient, without bridging (82, 83). Aspirin can be continued in most noncardiac surgeries; if discontinued, stop ≤ 7 days before. P2Y₁₂ inhibitors should be stopped: clopidogrel 5 days, ticagrelor 3-5 days, prasugrel 7 days (82).

Recommendations by Procedure:

- **Extracorporeal Shock Wave Lithotripsy (ESWL):** Moderate-to-high bleeding risk. Therapeutic-dose Low Molecular Weight Heparins (LMWH) is an independent predictor of renal hematoma (OR 10.4). Aspirin also increases hematoma risk. Discontinuing therapeutic LMWH is recommended, and risk-benefit assessment should be performed for aspirin (81).
- **Ureteroscopy (URS):** Low-to-moderate bleeding risk. AUA guidelines state that continuing aspirin is safe. Because it is the technique with the lowest risk of bleeding, it should be the preferred method whenever possible in patients on anticoagulants and/or antiplatelet therapy. A meta-analysis confirmed similar success rates (90.8% vs 86.2%), though with higher bleeding-related complications in anticoagulated patients (81, 84, 85).
- **Percutaneous Nephrolithotomy (PCNL):** High bleeding risk. Requires discontinuation protocol: warfarin 5 days before, DOACs 2 days, clopidogrel 5-7 days. Studies demonstrate that with appropriate protocols, success rates (78% vs 74%) and hemorrhagic complications (12% vs 9%) are comparable to patients without antithrombotic therapy. Low-dose aspirin can be safely continued in selected cases (81).

Table 5.

Anticoagulants and Antiplatelet agents.

Class	Drugs	Mechanism	Use
Anticoagulants	Warfarin direct oral anticoagulants (DOACs) heparins	Inhibition of coagulation cascade	Prevent venous thrombosis and embolism in atrial fibrillation or mechanical heart valves
Antiplatelet agents	Aspirin, clopidogrel, ticagrelor	Inhibition of platelet function	Coronary artery disease, stents, and cardiovascular prevention

Conclusion: Individualized risk stratification of thromboembolic versus bleeding risk is essential. Ureterscopy is the safest procedure in anticoagulated patients, while PCNL requires more careful management. Routine bridging is no longer recommended for most patients (81, 82, 84, 85).

Renal damage in Shock Wave Lithotripsy (SWL), Retrograde Intrarenal Surgery (RIRS) and Percutaneous Nephrolithotomy (PCNL)

(M. Hammad Ather)

Innovations in endourological tools have enabled minimally invasive treatments for urolithiasis. Early excitement for new technology often mirrors a “honeymoon phase” with high expectations for gadgets and digital systems. Initially, PCNL and SWL were used to fragment every stone, but it soon became clear that SWL is not suitable for all stones (4). RIRS is now promoted as a universal solution. One major concern in managing upper tract urolithiasis is the risk of kidney damage, with mechanisms and extent varying across methods (86). SWL, introduced nearly 40 years ago, is a true *minimally invasive surgery* (MIS) guided by real-time monitoring, non-invasive, and often performed without anaesthesia (except in children). Ideal stones depend on size, density, location, body habitus, and composition. Risks include bruising, haematuria, Steinstrasse, and renal damage. Kidney injury from SWL occurs via mechanical trauma, cavitation bubbles, ischaemia-reperfusion injury, and, rarely, renal tubular damage. Acute effects include haemorrhage, contusion, and oedema, which are often self-limiting. However, repeated high-energy shocks can cause fibrosis, hypertension, and diabetes. Power ramping and low-energy settings help protect the kidneys (87). RIRS, now common for ureteral and kidney stones, has improved with technology, but it carries risks of kidney damage from high intrarenal pressure and heat from high-power lasers. Pressures above 40 cm of water imply risk of injury; spikes over 100 cm are frequent and dangerous, increasing the risk of backflow, bacterial translocation, and sepsis. Elevated pressures cause oedema and tissue damage, with markers such as NGAL, KIM1, and NAG indicating injury. Higher stone burden, longer procedures, diabetes, *chronic kidney disease* (CKD), *urinary tract infection* (UTI), and ureteral access sheaths increase risk (88). PCNL, the most invasive procedure, carries risks of trauma and vascular injury. High pressures are rare but can cause leakage and inflammation. Bacteria from stones can lead to sepsis and *acute kidney injury* (AKI). Risk factors include multiple accesses, prolonged procedures, single kidneys, CKD, and staghorn stones (89). Although *minimally invasive surgery* (MIS) reduces kidney damage compared with open surgery, all interventions carry a risk of CKD. Careful patient selection and staged procedures for large stones can minimize risks.

Bleeding in ESWL, RIRS, PCNL (Iraklis C. Mitsogiannis) *Extracorporeal Shockwave Lithotripsy* (ESWL). ESWL was introduced in 1980 as a non-invasive therapeutic approach and revolutionised treatment of urolithiasis, replacing traditional open surgery (90). Over the years, ESWL has been established as an efficacious treatment

modality, in particular for renal stones ≤ 2 cm and ureteric stones ≤ 1 cm in maximum diameter, with efficacy being dependant upon shock wave rate, proper acoustic coupling, power ramping and control of pain. Nevertheless, complications may occur and bleeding, presenting either as macroscopic haematuria or as subcapsular/perirenal haematoma may be severe or even life-threatening (91). Macroscopic haematuria is expected to occur in 17.25% of patients following ESWL (92) and is most commonly self-controlled (Clavien I complication) although blood transfusion may be required in some cases (Clavien II complication) (92). Asymptomatic or symptomatic haematomas are rarer, complicating ESWL with a reported incidence of 1.23% and 0.15%, respectively, however there are studies reporting a higher incidence of asymptomatic haematoma formation (up to 30.9%) in the early post-procedure period (93). Haematoma is considered to be the result of a complex interaction between shockwave physics and tissue biomechanics (94) and is dependent upon total energy delivered, shockwave characteristics and patient factors. Hypertension, high (> 30) BMI and older age as well as higher mean and maximum stone density are recognised risk factors; in contrast, stepwise voltage ramping, optimised shockwave (60-90/min) and meticulous pre-procedure workup are proven prevention measures (93, 95-97).

Ureterolithotripsy (URL)/*Retrograde Intrarenal Surgery* (RIRS). Advances in technology and equipment (ureteroscopes, laser devices), over the last years, have broadened indications for URL/RIRS which may currently be applied in more complex cases and higher-risk patients. Laser lithotripsy is a highly efficacious form of stone disintegration with a stone-free rate of 85.6% (98). The CROES URS Global Study reported an overall complication rate of 7.4%, with intra-operative and post-operative bleeding occurring in 1.41% and 0.45% of cases, respectively (99); the FLEXOR Registry, however, reported a higher incidence of post-RIRS bleeding requiring blood transfusion (5.5%) (100). Perirenal haematomas may complicate URL in 0.45% of cases with predisposing factors being hypertension, hydronephrosis, prolonged operation, preoperative *urinary tract infection* (UTI) and thin renal cortex (101). Prevention measures include control of hypertension, effective pre-op treatment of UTIs, intraoperative monitoring of the guidewire tip, maintenance of a constant decreased intrarenal pressure, use of gravity infusion and insertion of a JJ stent following the procedure (101, 102). Although renal haematomas may rarely be life-threatening, most cases are successfully treated conservatively, with percutaneous drainage and surgical intervention, including urgent renal angiography and embolization, required in 27.5% and 17.5% of cases, respectively (101, 103).

Percutaneous Nephrolithotomy (PCNL). PCNL has been established as an efficacious method for treating multiple or large renal calculi. Over the years, variations of the technique regarding patient position, imaging method for puncture, dilatation method, endoscope used and lithotripsy device have been introduced. PCNL is generally considered to be a safe operation, however complication do occur with fever and bleeding requiring blood

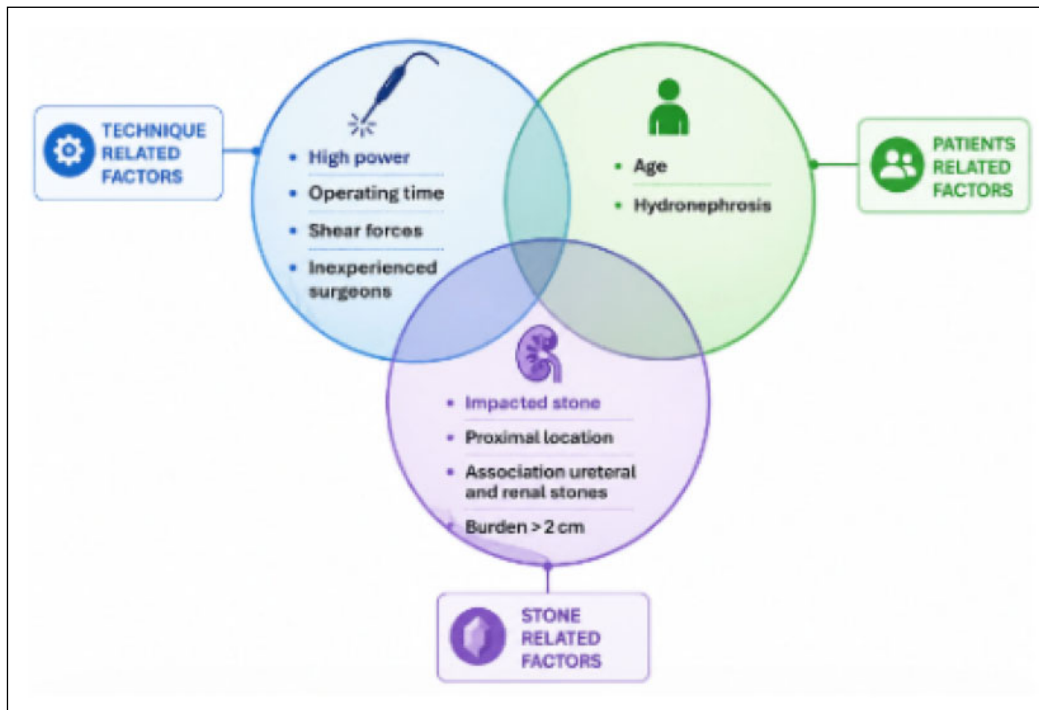


Figure 2.
Risk factors of
ureteral stricture post
stone surgery.

transfusion being the commonest (10.8% and 7.5% of cases, respectively) (104). Haemorrhage requiring blood transfusion has been reported to be related to larger tract size, multiple punctures, perforation of renal pelvis, staghorn calculi, supracostal puncture, prolonged operation, low preoperative haemoglobin levels and total blood loss (104, 105). Bleeding occurring intraoperatively may be venous or arterial, commonly resulting from injury of a segmental artery; delayed bleeding is usually indicative of *arteriovenous fistula* (AVF) or pseudoaneurysm formation (105). Acute haemorrhage may be controlled with insertion of a clamped, large-bore nephrostomy tube, however, in cases of intractable arterial bleeding, selective embolization of the bleeding vessel is mandatory (106). AV fistulae and pseudoaneurysms are rare (1.2% of cases) (106) and are characterised from persistent haematuria and progressive drop in haemoglobin level. Renal angiography and selective embolization is indicated should conservative management fail. Bleeding following PCNL may also occur in the form of renal haematomas, usually subcapsular haematomas. These may occur in 1/3 of cases and are most commonly asymptomatic, with only 1% requiring intervention (107).

Ureteral stricture post stone surgery (Jihad El Anzaoui)

Ureteral stricture after stone surgery is an uncommon but clinically important complication characterized by fibrotic narrowing of the ureter, which may cause persistent obstruction, recurrent infection, flank pain, hydronephrosis, and loss of renal function. Recent evidence suggests that the risk after ureteroscopy is not negligible: a 2024 systematic review reported a pooled stricture rate of 1.9%, increasing to 4.9% in impacted stones, while a population-based study found a rate of 2.9% after ureteroscopy

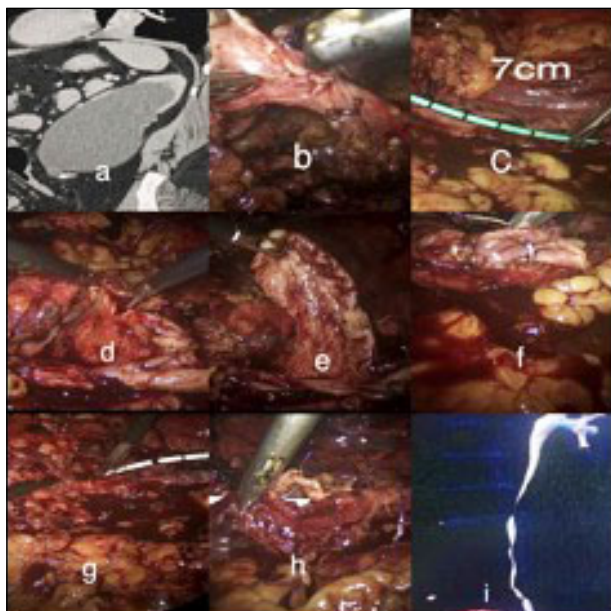
(108, 109). The pathophysiology is multifactorial and includes chronic inflammation from stone impaction, ischemic injury, mucosal trauma, ureteral perforation, and thermal damage during laser lithotripsy. The most consistently reported risk factors are impacted stones, proximal ureteral location, preoperative hydronephrosis, intraoperative perforation, large stone burden, prolonged instrumentation, and difficult procedures requiring repeated manipulation (Figure 2) (108-110).

In impacted stones, perforation and mucosal injury appear to be the strongest predictors of later stricture formation (110). Laser-related thermal injury deserves particular attention. Tissue damage may occur when intraluminal temperature rises above safe thresholds, especially with high power, prolonged activation, poor irrigation, and limited outflow. This concern may be greater with high-power settings and newer laser platforms if energy delivery is not carefully controlled. Preventive measures include gentle manipulation, the lowest effective power and frequency, short activation cycles ("on/off" firing), adequate irrigation and drainage, avoidance of direct mucosal contact, staged treatment when visibility is poor, and systematic postoperative imaging in high-risk cases (108, 111). Management depends on stricture length, location, etiology, and renal function. Short benign strictures may be treated endoscopically with dilation or endoureterotomy, but long, ischemic, recurrent, or complex strictures usually require reconstruction (Table 6) (Figures 3, 4). Contemporary trends favor minimally invasive reconstruction, particularly robotic ureteroplasty, including buccal mucosal graft ureteroplasty for selected complex cases, with encouraging early outcomes (111, 112). Overall, prevention remains the most effective strategy because ureteral stricture after stone surgery can lead to substantial morbidity and repeated interventions.

Table 6.

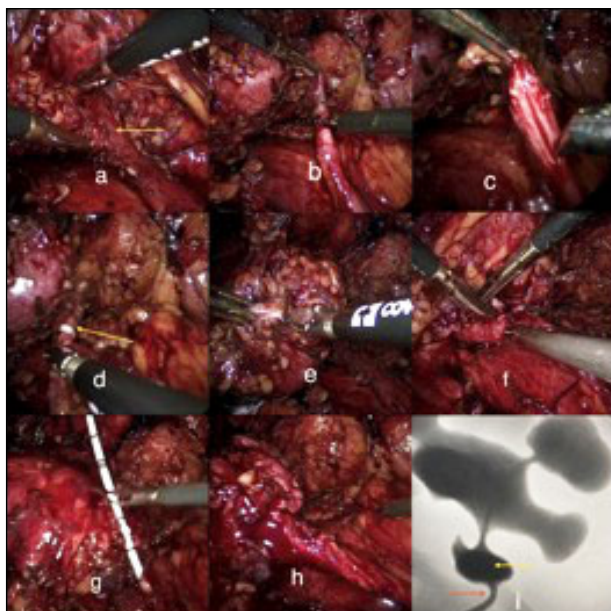
Surgical options for management of ureteral stricture post stone surgery according to its location.

URETERIC SEGMENT	UPJ & PROXIMAL URETER	MIDDLE URETER	DISTAL URETER
SURGICAL OPTIONS	BMG	Ureteroureterotomy	Appendix substitute (mostly right side)
	Renal pelvic flap	Appendiceal flap (mostly right side)	Ureteral reimplantation (+/- psoas hitch or Boari flap)
	Redo-pyeloplasty		
	Ileal ureter (+/- psoas hitch)	Ureteral reimplantation (+/- psoas hitch or Boari flap)	
	Renal autotransplantation		

**Figure 3.**

Laparoscopic renal pelvic flap for the management of an impacted stone associated with a ureteral stricture:

- CT scan showing a massively dilated renal pelvis proximal to an impacted stone associated with a ureteral stricture.
- Opening of the renal pelvis with extension of the longitudinal incision distally to healthy ureter beyond the stricture.
- A 7-cm-long ureteral stricture.
- Creation of a renal pelvic flap.
- Well-vascularized and adequately long renal pelvic flap.
- Suturing of the medial aspect of the flap to the medial aspect of the ureter.
- Insertion of a double-J ureteral stent.
- Suturing of the lateral aspect of the flap to the lateral aspect of the ureter, completing the reconstruction.
- Excretory-phase CT scan obtained 6 months postoperatively, demonstrating a patent reconstruction.

**Figure 4.**

Laparoscopic ureterocalicostomy for highly fibrotic ureteropelvic junction post stone endoscopic surgery:

- Dissection of the ureteropelvic junction. Red arrow: fibrotic and retracted renal pelvis. Yellow arrow: fibrotic proximal ureter.
- Transection of the ureter.
- Wide spatulation of the ureter.
- Ligation with a Hem-o-lok clip (yellow arrow) followed by transection of the proximal ureter.
- Opening of the lower calyx using a LigaSure device.
- Suturing of the posterior wall of the ureterocalicostomy.
- Insertion of a double-J ureteral stent.
- Suturing of the anterior wall, completing the ureterocalicostomy.
- Contrast opacification on CT scan performed 6 months postoperatively, demonstrating a patent ureterocaliceal anastomosis.

ENCrustATION AND INFECTION

Innovative oral treatment to prevent stent encrustation (Oriol Angerri, Francesco Di Bello)

Ureteral double-J stents (DJs) play a pivotal role in both emergency setting and routine urological practice (113). These devices are widely used to relieve ureteral obstruction and to ensure adequate drainage of urine from the upper urinary tract (113). Furthermore, they are essential for decompressing the caliceal system, preserving ureteral patency and protecting renal function (113). While lifesaving, DJs carry significant morbidity, when not managed correctly. Common complications include lower urinary tract symptoms, pain, and infections (114). Notably, *stent encrustation* (SE) represents one of the most frequent and clinically significant adverse events, leading to complex management scenarios, the need for staged interventions, and increased healthcare costs (115, 116). According to risk factors, prolonged indwelling time is commonly associated with SE, with rates ranging from 26.8% at < 6 weeks to 75.9% at > 12 weeks, followed by history of urolithiasis, anatomical abnormalities and comorbidities, such as metabolic disorders, pregnancy and chronic renal failure (113). However, its etiology is multifactorial, and involves the interaction between urinary composition, bacterial colonization, and the DJ biomaterial (117). The formation of a bacterial biofilm on the stent surface plays a central role, acting as a scaffold for crystal nucleation and growth. Specifically, urease-producing microorganisms, such as *Proteus mirabilis*, increase urinary pH and promote the precipitation of struvite and calcium phosphate crystals, accelerating the encrustation process (117, 118). From a clinical perspective, encrusted stents represent a major challenge (114). Importantly, many of these complications are preventable (114). Strategies such as minimizing indwelling time, ensuring high-quality patient education, following strict follow-up protocols, optimizing stent material selection, and modifying the urinary environment are essential (113, 114, 117). In this regard, silicone DJs are currently considered the best biomaterial for enhancing patient tolerance and reducing complications (119). Moreover, while various surface coatings (anti-adhesive or antimicrobial) have been explored, none have yet been shown to prevent biofilm formation to a clinically relevant degree. As modifier of urinary environment, Canoxidin® represents a significant advancement in this area, coupling of L-methionine, phytate and theobromine (117). While L-Methionine acidifies urine to counteract the alkalinization caused by urease-producing bacteria, phytate and theobromine specifically inhibits the crystallization of calcium oxalate and hydroxyapatite and uric acid and urate salts, respectively (117). As such, patients treated with Canoxidin® are associated with 95% lower odds of SE compared to the placebo group (odds ratio [OR]: 0.05; confidence interval [CI]: 0.004-0.6, p value 0.019) (117). Taken together, SE remains a common but preventable complication, and its risk can be significantly modulated through appropriate DJs management strategies and control of the urinary environment.

Non-antibiotic approaches for UTIs

(Guzmán Ordaz Jurado)

UTIs are among the most common infectious diseases, affecting up to 50-60% of women at least once in their lifetime, with a significant proportion developing recurrent infections. The primary causative agent is *uropathogenic Escherichia coli* (UPEC), which colonizes the urinary tract through migration from the intestinal reservoir.

Urinary acidification is a key non-antibiotic strategy. Through the metabolism of L-methionine, urinary pH can be reduced to around 5.0, creating a hostile environment for bacterial survival. Acidic conditions disrupt bacterial membranes, denature proteins, impair enzyme activity, and alter metabolic pathways, ultimately reducing bacterial growth, virulence, and biofilm formation. Additionally, acid stress can trigger programmed bacterial cell death mechanisms.

Importantly, urinary acidification also enhances the effectiveness of certain antibiotics. For example, fosfomycin demonstrates significantly increased activity at lower pH levels, with efficacy potentially increasing up to 30-fold. This synergistic effect allows for improved treatment outcomes while potentially reducing antibiotic use and resistance.

Phytate is presented as a complementary mechanism with multiple antimicrobial effects. It acts primarily through iron chelation, depriving bacteria of a critical nutrient required for growth and metabolism. Phytate also interferes with biofilm formation, inhibits bacterial adhesion to the urothelium, and disrupts protein synthesis by chelating essential minerals. These effects significantly reduce bacterial proliferation and persistence in the urinary tract.

DECLARATIONS

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Availability of data and material: From the corresponding author upon reasonable request.

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Clinical data support the effectiveness of these strategies. L-methionine has been shown to reduce the incidence of recurrent UTIs by approximately 49% in preventive settings and to significantly improve outcomes in symptomatic infections compared to control groups (120, 121). In conclusion, non-antibiotic approaches such as urinary acidification and phytate supplementation (Metiofitina®) offer a promising, multifaceted strategy for managing UTIs. By targeting bacterial survival mechanisms, enhancing antibiotic efficacy, and reducing recurrence rates, these interventions may help decrease antibiotic dependence and combat antimicrobial resistance, representing a shift toward more sustainable and preventive urological care.

CONCLUSIONS

The meeting participants remembered Noor Buchholz, the creator and founder of ESD, in whose memory they continue to meet every year with the same vision of a multidisciplinary approach to the study and management of urinary stone disease.

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