The Evolving Landscape of Kidney Stone Management: What Every PA Should Know

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Objectives

- Review epidemiology and pathophysiology of nephrolithiasis
- Discuss basic medical management of nephrolithiasis
- Understand the various surgical options for treatment of nephrolithiasis

Epidemiology & Burden

- Affects ~10% of adults; prevalence rising with obesity, diabetes, metabolic syndrome, and climate (Rule et al., *JAMA*, 2020)
- Lifetime recurrence up to ~50% within 5 years of a first stone (Terro et al., *World Journal of Urology*, 2026)
- Major driver of ED visits: ~550,000 U.S. emergency visits annually for ureteric colic (Pickard et al., *Lancet*, 2015)
- Higher incidence in men and in hot/arid climates

Basic Pathophysiology

- Stones form when urine becomes **supersaturated**, tipping the balance between crystallization **promoters** (calcium, oxalate, phosphate, urate, cystine) and **inhibitors** (citrate, magnesium)
- Low urine volume is the single most important modifiable driver
- Three formation pathways (Bargagli et al., *Nature Reviews Nephrology*, 2025):
  1. **Free-particle** — nucleation and aggregation in supersaturated urine
  2. **Randall plaque** — apatite deposits in loop-of-Henle basement membrane extend to papillary surface, becoming a nidus for calcium oxalate (idiopathic CaOx formers)
  3. **Tubular plug** — crystal plugs in inner medullary collecting/Bellini ducts (alkaline urine states, e.g., hyperparathyroidism, obesity)

Stone Types

Stone type	Approx. frequency	Key associations
Calcium oxalate	Most common (majority of >80% Ca stones)	Hypercalciuria, hyperoxaluria, hypocitraturia, low volume; pH-independent
Calcium phosphate	Common, often mixed	Alkaline urine (pH >6.5), RTA, hyperparathyroidism
Uric acid	~5–10%	Acidic urine (low pH), gout, obesity/insulin resistance; radiolucent
Struvite (Mg-ammonium-phosphate)	"Infection stones"	Urease-producing bacteria (Proteus); can form staghorn calculi
Cystine	Rare	Autosomal recessive cystinuria; early onset, recurrent

Risk Factors

- **Dietary:** low fluid intake, high sodium, high animal protein, high oxalate, low dietary calcium (Kulsoom et al., *Urolithiasis*, 2025)
- **Metabolic/systemic:** obesity, type 2 diabetes, gout, hyperparathyroidism, RTA, IBD/malabsorption, recurrent UTIs
- **Genetic/familial:** positive family history increases risk ~2.5-fold; hypercalciuria (present in ~60% of adult calcium stone formers) often runs in families
- **Medications:** loop/thiazide misuse, topiramate, acetazolamide, triamterene, protease inhibitors
- **Environmental:** hot climate, dehydration, high occupational heat exposure

Clinical Presentation

- **Renal colic:** acute, severe, unilateral flank pain radiating to groin; patient often writhing/restless
- Nausea, vomiting, hematuria (gross or microscopic), dysuria, urinary urgency
- Ureteral stones may present incidentally, with obstruction, or with infection
- **Red flags requiring urgent urology involvement:** fever/sepsis, solitary or transplanted kidney, bilateral obstruction, acute kidney injury, uncontrolled pain/vomiting

Diagnostic Workup

- **Non-contrast CT** is the imaging gold standard — best delineates size, location, density (Hounsfield units) (Rule et al., *JAMA*, 2020)
- **Ultrasound** — radiation-free, preferred in pregnancy and for recurrent/young patients; may miss small stones
- Plain **KUB** radiograph is insufficient for initial diagnosis
- **Labs**: urinalysis, urine culture, CBC, BMP (creatinine), calcium, uric acid; retrieve/strain stone for composition analysis
- Stone size and location drive management decisions

Acute management of renal colic

- **Pain control:** NSAIDs (e.g., IV ketorolac) provide analgesia at least equal to opioids in renal colic and are first-line when not contraindicated (avoid in AKI/CKD, GI bleed risk) (Bargagli et al., *Nature Reviews Nephrology*, 2025)
- Opioids reserved for severe or refractory pain
- IV fluids for volume depletion; fluids do **not** hasten stone passage
- Antiemetics as needed
- Assess for red flags (fever, obstruction, AKI, solitary kidney) at every visit

Trial of Passage & Medical Expulsive Therapy

- A trial of spontaneous passage is appropriate for **uncomplicated ureteral stones ≤10 mm** (AUA) (Sussman et al., 2023; Rule et al., *JAMA*, 2020)
- Passage likelihood depends on size and location: distal stones <5 mm pass ~89%; upper-tract stones >7 mm pass only ~14%
- **MET with alpha-blockers (tamsulosin)** improves passage, especially for larger (>5 mm) distal ureteral stones; ~44% higher passage rate in 5–10 mm stones (Rule et al., *JAMA*, 2020; Pickard et al., *Lancet*, 2015)
- Alpha-blocker use for MET is off-label but strongly endorsed by AUA/EAU; also has analgesic benefit
- Refer for intervention if no passage after **4–6 weeks**, or sooner for complications/patient preference

Who Needs Metabolic Evaluation?

- **Basic evaluation** for all stone formers: stone composition, serum chemistries, urinalysis
- **Comprehensive metabolic evaluation (24-hr urine ×2)** for high-risk or recurrent stone formers and motivated first-time formers (AUA; IAU guidelines, Zeng et al., *Urolithiasis*, 2022)
- **High-risk features:** early onset (<18–25 yr), family history, bilateral/multiple stones, recurrent stones, uric acid or cystine stones, brushite/pure calcium phosphate, solitary kidney, GI disease, hyperparathyroidism, nephrocalcinosis
- 24-hr urine: volume, pH, calcium, oxalate, citrate, uric acid, sodium, creatinine (adequacy); collect ≥3 months after acute event on usual diet

Dietary Prevention

- **Fluids:** goal urine output ≥2.5 L/day (target intake ~2.5–3.0 L/day) — strongest evidence (Asher et al., *Annals of Internal Medicine*, 2026)
- **Sodium:** restrict — high sodium increases urinary calcium
- **Protein:** moderate animal protein intake
- **Calcium:** maintain normal-to-adequate dietary calcium (1.0–1.2 g/day); low-calcium diets increase oxalate absorption and worsen stones
- **Oxalate:** limit high-oxalate foods in hyperoxaluric CaOx formers
- **Citrate:** increase fruits/vegetables to raise urinary citrate

Pharmacologic Prevention

Agent	Indication	Mechanism/effect
Thiazide diuretic	Hypercalciuria, recurrent Ca stones	Reduces urinary calcium
Potassium citrate (alkali)	Hypocitraturia, uric acid stones, RTA	Raises urinary citrate & pH
Allopurinol	Hyperuricosuric calcium oxalate stones	Lowers uric acid
Alkali therapy	Uric acid stones	Urinary alkalinization dissolves/prevents
Acetohydroxamic acid	Struvite (infection) stones	Urease inhibitor (significant side effects)

When to Intervene Surgically?

- Failure of spontaneous passage (≥4–6 weeks) of MET
- Uncontrolled pain, nausea/vomiting
- Obstruction with infection (**emergency** — urgent decompression via stent or percutaneous nephrostomy + antibiotics)
- AKI, solitary/transplant kidney, bilateral obstruction
- Large stone burden unlikely to pass
- Elective options for flank pain with non-obstructing ipsilateral stones, or recurrent UTIs with calyceal stones (AUA, 2025)

Surgical Modalities Overview

- **Shock Wave Lithotripsy (SWL):** noninvasive; external shock waves fragment the stone for passage. Less invasive, lower stone-free rate; start low-energy and ramp up to limit bleeding (AUA, 2025)
- **Ureteroscopy (URS):** retrograde scope with laser (holmium/thulium) lithotripsy; versatile for ureteral and renal stones
- **Percutaneous Nephrolithotomy (PCNL):** percutaneous tract into kidney; highest stone-free rate for large/complex stones; mini-PCNL available
- Choice depends on stone size, location, density, anatomy, and patient/surgeon factors (Setthawong et al., *Cochrane*, 2023)

AUA Guideline: Kidney Stone Treatment Selection (2025)

- **<1 cm lower pole:** SWL, URS, or percutaneous approach after shared decision-making (Expert Opinion)
- **>1 cm lower pole or >2 cm non-lower pole:** do **not** offer SWL first-line (Expert Opinion)
- **>1 cm lower pole:** PCNL has a higher stone-free rate than SWL or URS (Strong Rec, Grade A)
- **1–2 cm stones:** mini-PCNL may be offered over URS for higher stone-free rates (Conditional, Grade B)
- **>2 cm stones:** PCNL is first-line therapy (Moderate Rec, Grade B)
- **For <2 cm lower pole URS**: reposition stone superiorly before lithotripsy when feasible (Moderate, Grade B)

Ureteral Stone Surgical Management

- First-line for many ureteral stones: **URS or SWL** (high guideline consensus) (Jiang et al., *Journal of Urology*, 2021)
- Larger/impacted upper ureteral stones: URS increasingly favored (EAU: URS first-line for stones >10 mm)
- PCNL/antegrade approaches reserved for large, impacted, or failed retrograde access cases
- No pre-stenting needed for uncomplicated URS
- Alpha-blocker MET recommended as adjunct

Pregnancy: What Changes vs Standard Stone Care

- AUA recommends conservative, multidisciplinary management first-line; coordinate all intervention with obstetrics (AUA Clinical Principle).

Standard (non-pregnant)	Pregnancy variation
Non-contrast CT first-line imaging	**Ultrasound first-line**; non-contrast MRI or low-dose CT if needed
NSAIDs first-line for renal colic	**Avoid NSAIDs** (ductus arteriosus closure, oligohydramnios, preterm risk); use acetaminophen ± cautious opioids
Tamsulosin MET for distal stones	Tamsulosin **not shown to improve passage**; routine use not supported
PCNL standard for large stones	**PCNL generally contraindicated**

Observation & Intervention (Pregnancy)

- **Observation with trial of passage** is first-line for controlled symptoms (passage ~40–60%; mean ~17–35 days)
- **Reserve intervention** for failed passage, intractable symptoms, or complications
- When intervention needed:
  - **Ureteroscopy (URS)** for definitive treatment — safe, no increase in endoscopic complications vs. nonpregnant; ~4.3% obstetric complication risk (multicenter series: 95.8% stone-free, no serious fetal/obstetric complications); best in 2nd trimester
  - **Temporary drainage** (ureteral stent OR percutaneous nephrostomy) as alternative — requires **frequent exchanges (~every 4–6 weeks)** due to accelerated encrustation
  - **Avoid PCNL**

Emergencies & Key Takeaways (Pregnancy)

- **Urgent decompression (with obstetrics) for:**
  1. Obstruction with infection / sepsis
  2. Intractable pain, progressive hydronephrosis, preterm labor, or AKI
- **High-yield takeaways:**
  1. Ultrasound first — not CT
  2. **Avoid NSAIDs** — acetaminophen ± cautious opioids
  3. Most stones pass — conservative management first-line
  4. Intervention = URS or temporary drainage; **avoid PCNL**
  5. Always coordinate with obstetrics
  6. **Infection + obstruction = emergency**

Key Takeaways

- Supersaturation and low urine volume drive stone formation; calcium oxalate is most common
- NSAIDs are first-line for renal colic; tamsulosin aids passage of larger distal ureteral stones
- Trial of passage for uncomplicated stones ≤10 mm; intervene at 4–6 weeks or for red flags
- Prevention: high fluids, low sodium, normal calcium, targeted drugs (thiazide, citrate, allopurinol)
- Surgery by size/location: SWL/URS for smaller stones, **PCNL first-line for >2 cm**; urgent decompression for obstruction + infection

Clinical Scenario #1

- **Patient:** 34-year-old man, no significant PMH
- **Presentation:** Sudden-onset severe right flank pain radiating to the groin, nausea, one episode of vomiting; afebrile, hemodynamically stable
- **Exam:** Right costovertebral angle tenderness; abdomen soft
- **Labs:** Urinalysis with microscopic hematuria; **no pyuria, no nitrites**; normal WBC; creatinine normal
- **Imaging:** Non-contrast CT — **4 mm stone in the distal right ureter**, mild hydronephrosis, no signs of infection

Clinical Scenario #1 Management

- **Conservative, outpatient management is appropriate**
  - **Pain control (first-line):** NSAIDs (e.g., IV ketorolac) provide analgesia equal or superior to opioids in renal colic; reserve opioids for severe or refractory pain. Avoid NSAIDs if AKI/CKD or bleeding risk.
  - **Antiemetics** and **IV fluids** if volume-depleted
  - **Trial of spontaneous passage:** Recommended for uncomplicated ureteral stones ≤10 mm; a 4 mm distal stone passes in ~80–90% of cases
  - **Medical expulsive therapy (MET):** Offer daily **tamsulosin 0.4 mg** — most benefit for distal stones 5–10 mm (off-label); improves passage rate and provides analgesia
- **Disposition & safety-netting**
  - Discharge home with analgesics, antiemetics, and strainer for stone capture
  - **Urology follow-up / re-imaging in 4–6 weeks;** consider surgery if not passed
  - **Return precautions:** fever, chills, uncontrolled pain/vomiting, decreased urine output

Clinical Scenario #2

- **Patient:** 58-year-old woman, type 2 diabetes, recurrent UTIs
- **Presentation:** 2 days of left flank pain, now with **fever 39.2°C, rigors, dysuria**; tachycardic (HR 118), BP 96/58, ill-appearing
- **Exam:** Marked left CVA tenderness
- **Labs:** WBC 18,000; **urinalysis with pyuria, positive leukocyte esterase and nitrites**; lactate elevated; creatinine rising (AKI)
- **Imaging:** Non-contrast CT — **9 mm obstructing left proximal ureteral stone with hydronephrosis**

Clinical Scenario #2 Management

- **Obstruction + infection = urosepsis → emergent decompression**
  - Antibiotics alone will NOT resolve infection behind an obstruction; attempting definitive stone removal on an infected system risks life-threatening sepsis
  - **Delaying decompression ≥2 days is associated with ~29% higher odds of death**; mortality rises steeply with untreated septic shock
- **Immediate management (act in parallel)**
  - **Resuscitate:** IV fluids, hemodynamic support per sepsis protocols
  - **Broad-spectrum IV antibiotics** after blood and urine cultures
  - **Urgent urology consult** for renal drainage
  - **Decompression** via **ureteral stent OR percutaneous nephrostomy** (both equally effective; choice per urology/IR and local resources)
  - **Delay definitive stone treatment** until infection fully treated and sepsis resolved

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