

Stone disease

Mohammad Abufaraj

Assistant Professor of Urology

The University of Jordan

Adjunct Professor of Urology

Medical University of Vienna

Co-Editor

Arab Journal of Urology



Definition



- Presence of a solid, crystal material anywhere from the nephrons to the distal urinary tract
- (Nephrolithiasis, ureterolithiasis, cystolithiasis, urethrolithiasis)



Epidemiology



- The lifetime risk of renal calculi is approximately 12%.
- Male :Female is 3:1; due to discrete metabolic/ hormonal influences.
- The peak age of stone-related clinical episode in men is in the third decade. In women the peak incidence is in post- menopausal years.
- The incidence also varies in different populations.





Risk Factors

- A prior history of nephrolithiasis
- Family history of stones
- Stone disease is more common in individuals with diabetes, obesity, gout, and hypertension
- Low fluid intake and diet
- Malabsorption (gastric bypass, short bowel syndrome)
- Frequent upper urinary tract infections
- Use of medications that crystalize in urine (acyclovir, triamterene)
- Bowel resection
- Gout
- Hyperparathyroidism





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50% of patients may have a new episode of nephrolithiasis within 10 years

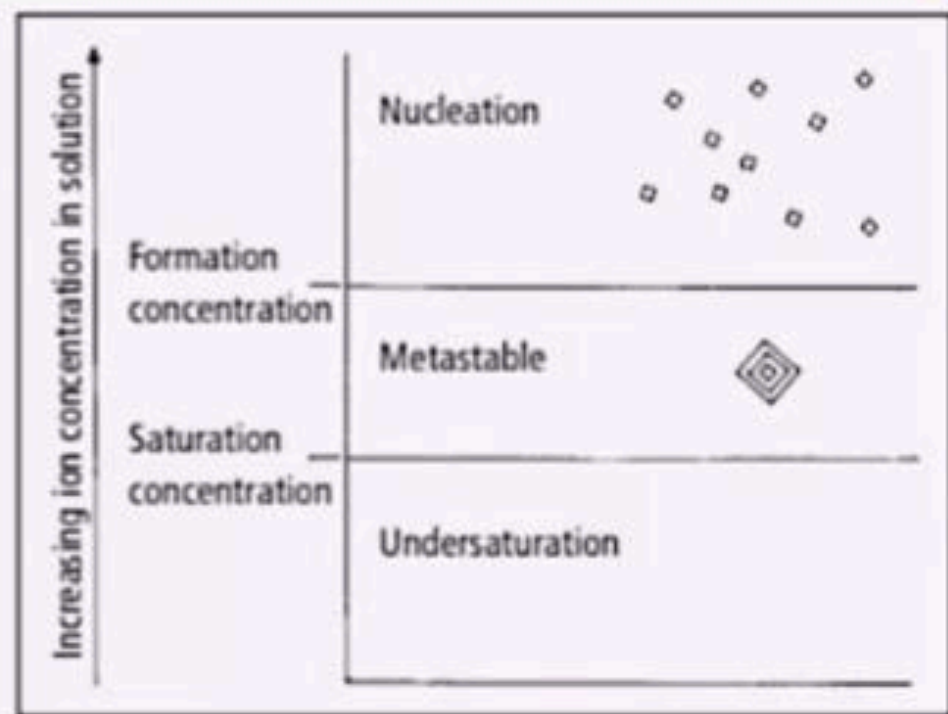


Pathophysiology



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- Supersaturation
- Crystallization
- Growth



Classification



- Calcium Stones
- Oxalate Stones
- Uric Acid Stones
- Cystine Stones
- Struvite Stones
- Medication-related stones



Calcium Stones

- Absorptive hypercalciuria
- Renal hypercalciuria
- Resorptive hypercalciuria



Calcium Stones



- **Calcium Oxalate**
 - Incidence- 80% MOST COMMON
 - Acidic urine
 - Color: Black/brown
 - Radio-opaque
- **Calcium phosphate**
 - Incidence - 5-10%
 - Alkaline urine (esp when Proteus present)
 - Color dirty white
 - Radio opaque
 - RTA predisposes to Ca phosphate stones



Oxalate Stones



- Is the most common type of urinary tract stones.
- -It may be due to :
 - Hepatic Oxaluria
 - Rare, autosomal recessive disorder of metabolism
 - Enteric Oxaluria
 - Most common, chronic diarrhea and fat malabsorption
 - Dietary Oxaluria

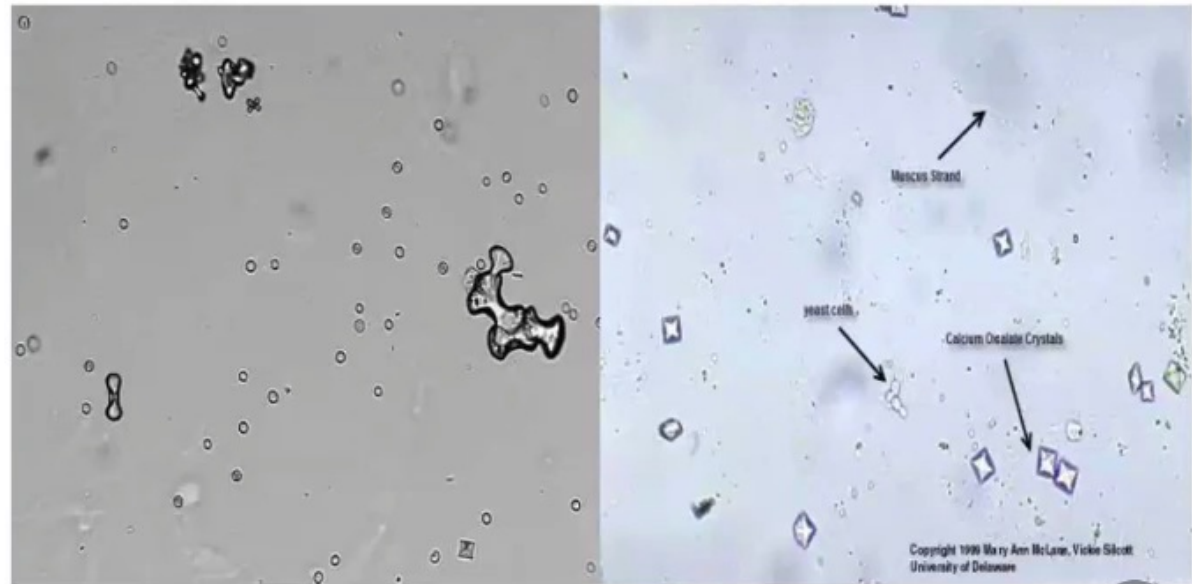


Calcium oxalate crystals



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- Biconcave dumbbells or bipyramidal envelopes
- Develop in acidic urine.



Uric Acid Stones



- Prevalence: 6%
- Low urine pH (Urine Ph is less than 5.5)
- Metabolic syndrome, insulin resistance and diet rich in animal protein

- Hyperuricemia
- Increased tissue breakdown and protein catabolism in association with chemotherapy for certain malignancies

- Pure uric acid stones are radiolucent. Commonly, they act as a nidus for calcium oxalate and calcium phosphate precipitation in which they become radio-opaque.





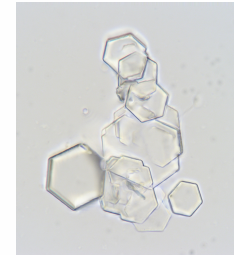
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- Rhomboid shape



Cystine Stones

- Prevalence: 1-2%
- In the setting of acidic urine
- Cystinuria
- Autosomal recessive disorder characterized by defective intestinal or renal tubular transport of dibasic amino acids (COAL–cystine, ornithine, arginine, lysine)
- Most frequent cause of stones in children



hexagonal-shaped
crystals



Struvite Stones



- Recurrent urinary tract infection
- Elderly, women, diabetics, urinary tract abnormalities and spinal cord injury.
- Magnesium ammonium phosphate
- Urine pH > 7
- Urease producing bacteria (proteus, pseudomonas, staphylococcus)
- Urease hydrolyses urinary urea into ammonium with resultant alkalinisation of urine
- May cause **staghorn stone** if left untreated





- rectangular prisms (coffin lid-appearance)





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Types	Incidence	Etiology/associated findings	Urine pH	Crystal appearance	Radiopacity	Prophylaxis
Calcium oxalate stones	<ul style="list-style-type: none"> ~ 75% 	<ul style="list-style-type: none"> Hypercalciuria Hyperoxaluria Hypocitraturia Can result from increased intake of <ul style="list-style-type: none"> Ethylene glycol (antifreeze) Vitamin C Associated with inflammatory bowel disease, i.e., ulcerative colitis and Crohn disease due to malabsorption 	<ul style="list-style-type: none"> ↓ Urine pH (acidic) 	<ul style="list-style-type: none"> Biconcave dumbbells or bipyramidal envelopes 	<ul style="list-style-type: none"> Radiopaque 	<ul style="list-style-type: none"> Urine alkalinization
Uric acid stones	<ul style="list-style-type: none"> ~ 10% 	<ul style="list-style-type: none"> Gout, hyperuricemia, and hyperuricosuria High cell turnover (e.g., leukemia, chemotherapy) 	<ul style="list-style-type: none"> ↓ Urine pH (acidic) and volume (often seen in desert climates) 	<ul style="list-style-type: none"> Rounded rhomboids, rosettes, or needle-shaped 	<ul style="list-style-type: none"> Radiolucent 	<ul style="list-style-type: none"> Urine alkalinization
Struvite stones	<ul style="list-style-type: none"> ~ 5-10% 	<ul style="list-style-type: none"> UTI with urease-producing bacteria (e.g., <i>Proteus mirabilis</i>, <i>S. saprophyticus</i>, <i>Klebsiella</i>) 	<ul style="list-style-type: none"> ↑ Urine pH (alkalic) 	<ul style="list-style-type: none"> Rectangular prisms (coffin lid-appearance) 	<ul style="list-style-type: none"> Weakly radiopaque 	<ul style="list-style-type: none"> Urine acidification
Calcium phosphate stones	<ul style="list-style-type: none"> < 5% 	<ul style="list-style-type: none"> Hyperparathyroidism Type 1 renal tubular acidosis 	<ul style="list-style-type: none"> ↑ Urine pH (alkalic) 	<ul style="list-style-type: none"> Wedge-shaped prisms 	<ul style="list-style-type: none"> Radiopaque 	<ul style="list-style-type: none"> Urine acidification
Cystine stones		<ul style="list-style-type: none"> Cystinuria (hereditary) 	<ul style="list-style-type: none"> ↓ Urine pH (acidic) 	<ul style="list-style-type: none"> Hexagon-shaped 	<ul style="list-style-type: none"> Weakly radiopaque 	<ul style="list-style-type: none"> Urine alkalinization
Xanthine stones		<ul style="list-style-type: none"> Xanthinuria (hereditary) 	<ul style="list-style-type: none"> Generally independent of urine pH 	<ul style="list-style-type: none"> Amorphous 	<ul style="list-style-type: none"> Radiolucent 	<ul style="list-style-type: none"> N/A



History



- **Symptoms:** pain, hematuria, N/V
- **Past medical & surgical history:** stones, UTI, gout, hyperparathyroidism ...
- **Family history**
- **Drug history:** chemotherapy, Ca++, diuretics ...
- **Social history:** fluid intake, diet



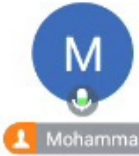
Kidney Stones



- Asymptomatic
- Flank pain, non radiating
- Hematuria (microscopic or occasionally macroscopic)
- Recurrent UTI
- Malaise, weakness, loss of appetite, N/V



Ureteral Stones



- Sudden onset of severe colicky flank pain
- Pain radiates to groin, testicles or labia majora
- Hematuria (microscopic or gross)
- N/V, pallor, sweating



Bladder Stone



- Consist of struvite or uric acid
- They occur in males over 50 that have a voiding defect due to bladder obstruction also occur in chronic cath patients.
- Asymptomatic (and incidentally found on KUB X-ray, bladder ultrasound or cystoscopy)
- Suprapubic or perineal pain
- Hematuria
- Urgency
- Recurrent UTI
- Poor flow
- Hesitancy



Investigation



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- Urine analysis and culture
- Metabolic workup (calcium, uric acid, creatinine, urea)
- Any stone should be analyzed by x-ray crystallography.
- CBC
- KFT





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- **KUBx-ray:**(initial imaging for follow up and to know if its radiolucent or opaque)
 - **Radio-opaque:** calcium containing(Ca oxalate, Ca phosphate)
 - **Relatively Radiolucent (radiofaint):** struvite and cysteine
 - **Completely radiolucent:** uric acid



This is a K. U. B x Ray showing stone at the middle of the left ureter

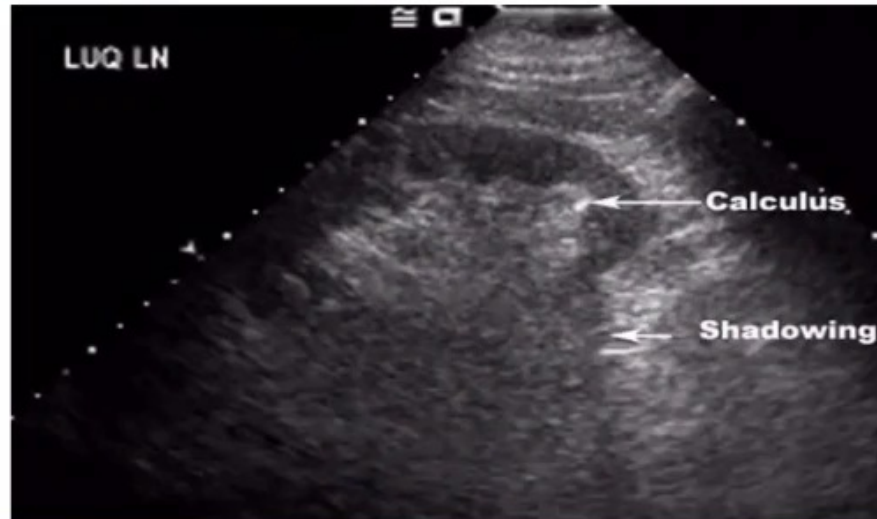


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Imaging Studies

- **Ultrasound:** (hydronephrosis, misses 30% of stones)
- Stones appear only in kidney,
- Stones do not appear if they are in ureter



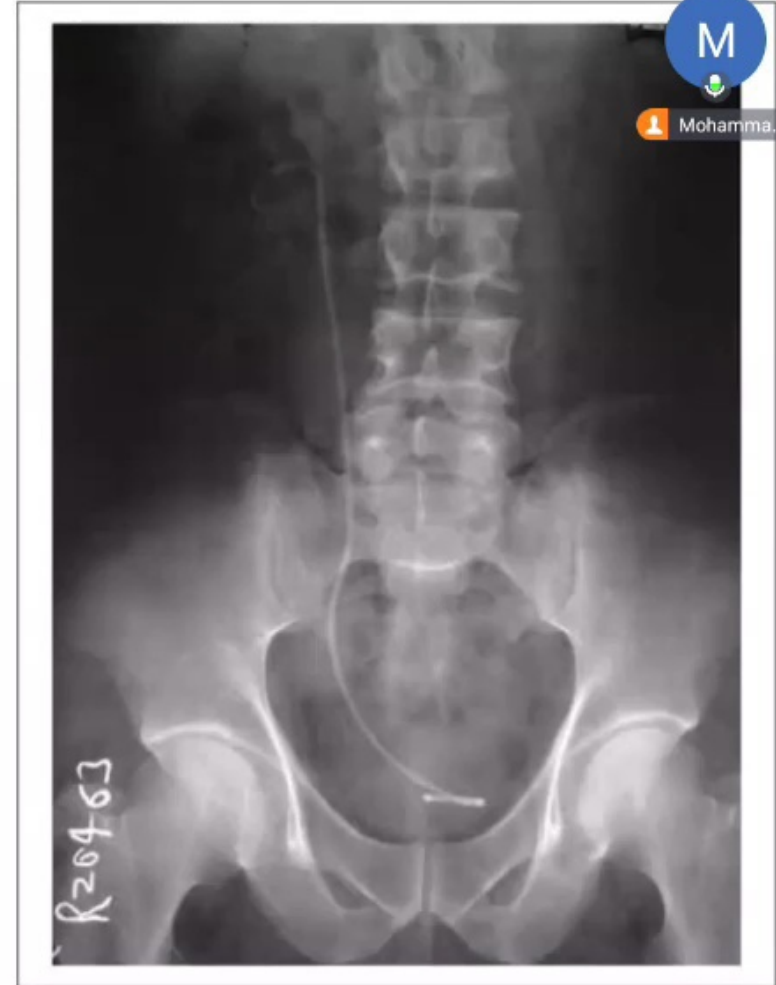
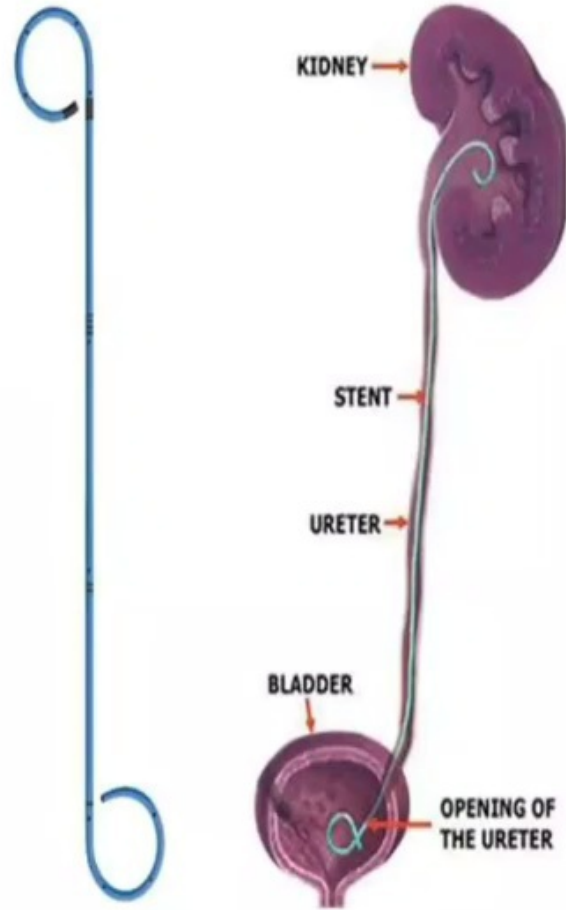
Imaging Studies

- **Non contrast enhanced CT scan:** gold standard for diagnosis



Management

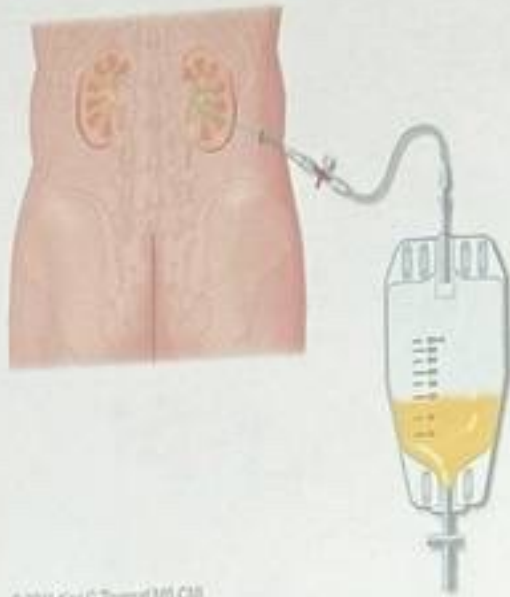
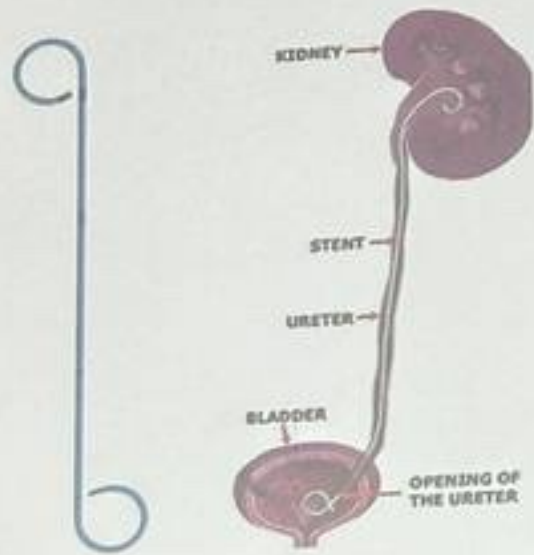
- Analgesia
- IV fluid
- Double J-stent placement



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- Choice of decompression method:
- JJ ureteral stent: preferred if retrograde access possible
- Percutaneous nephrostomy: preferred in severe sepsis, or when retrograde passage is not feasible



Indications for Urgent JJ Stent or Nephrostomy

- Obstructed kidney with **infection / sepsis**
- Obstruction in a **solitary kidney**
- **Bilateral ureteric obstruction**
- **Rising serum creatinine / acute kidney injury**
- **Intractable pain** not responding to analgesics
- **Intractable vomiting** preventing oral intake



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Definitive Management Options of Stone Disease

- Medical Expulsive Therapy (MET) (Facilitated spontaneous stone passage)
- Chemical dissolution
- Shock Wave Lithotripsy (ESWL)
- Ureteroscopy (semirigid or flexible) (Retrograde Intrarenal Surgery (RIRS))
- Percutaneous Nephrolithotomy (PCNL)
- Open or laparoscopic stone surgery (rare, selected cases)

Medical Expulsive Therapy (MET)

- **Agents:**

Alpha-blockers (tamsulosin 0.4 mg daily – first-line)

Calcium channel blockers (less commonly used)

NSAIDs if no contraindications for pain and reducing ureteral inflammation

- **Probability of Stone Passage:**

<5 mm stones: **70–98%**

5–10 mm stones: **35–50%**

10 mm stones: very low (<10%)

Used usually for: small & distal stones



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Chemical Dissolution (Alkalinization)

- **Definition:**

Medical dissolution therapy aims to dissolve uric acid stones by raising urine pH.

- **Alkalinization of Urine - Meaning:**

Increasing urine pH with potassium citrate or sodium bicarbonate to keep uric acid in soluble form.

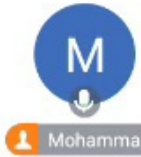
- **Indications:**

Uric acid stones

Cystine stones

Prophylaxis of uric acid stone recurrence

Not effective for calcium oxalate or struvite stones



ESWL (Extracorporeal Shock Wave Lithotripsy)

- **Mechanism of Action:**

Shock waves generated externally travel through soft tissue and fragment stones via:

Compressive and tensile forces

Cavitation bubble formation

Microfracture propagation

- **Contraindications:**

Pregnancy

Active UTI

Uncorrected coagulopathy

Severe skeletal deformities preventing positioning

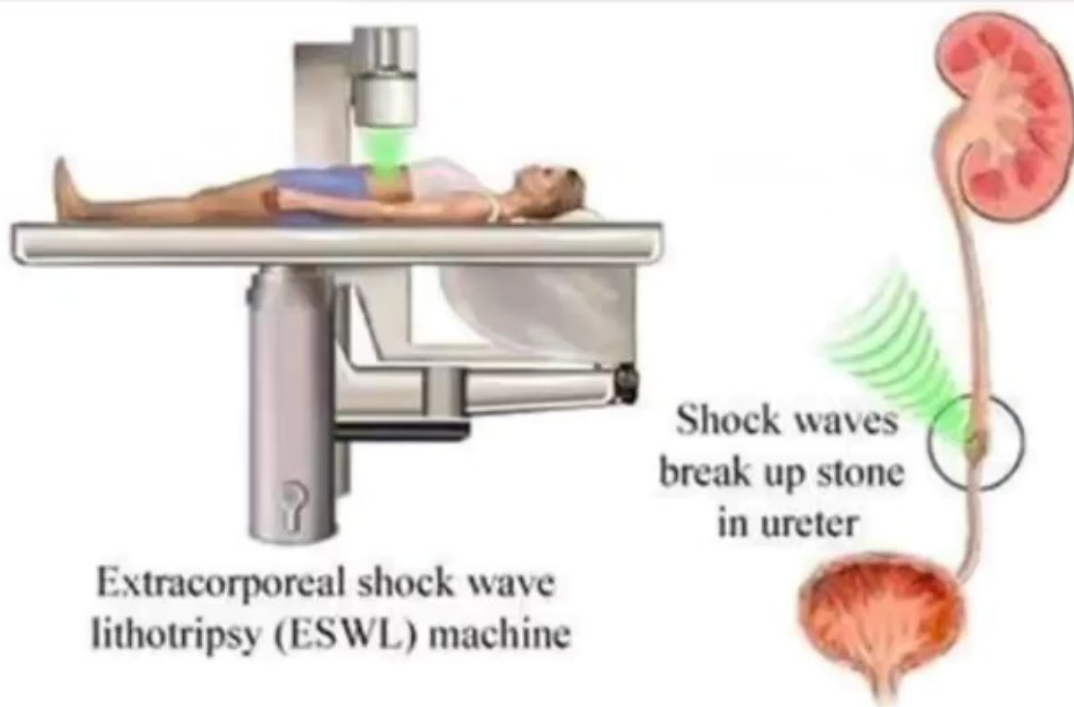
Aortic aneurysm in shock-wave path

Morbid Obesity preventing targeting (machine-dependent)



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Extracorporeal shock wave lithotripsy (ESWL) machine

Shock waves break up stone in ureter



RIRS (Retrograde Intrarenal Surgery)

- **Meaning:**
Endoscopic treatment of renal stones using a flexible ureteroscope introduced through the urethra and ureter.
- **Contraindications:**

Active UTI

Note: Tight ureter may need dilation or JJ insertion before proceeding with the procedure

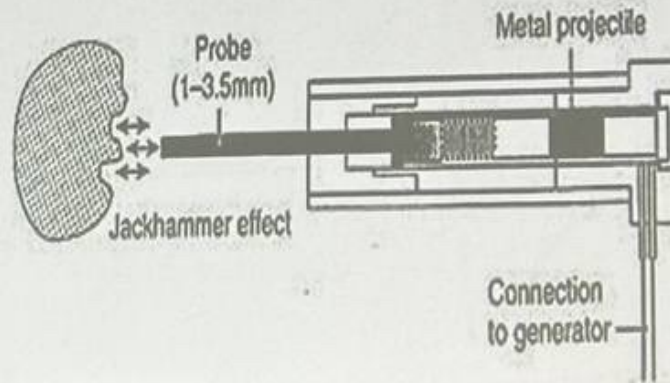


Retrograde intrarenal surgery

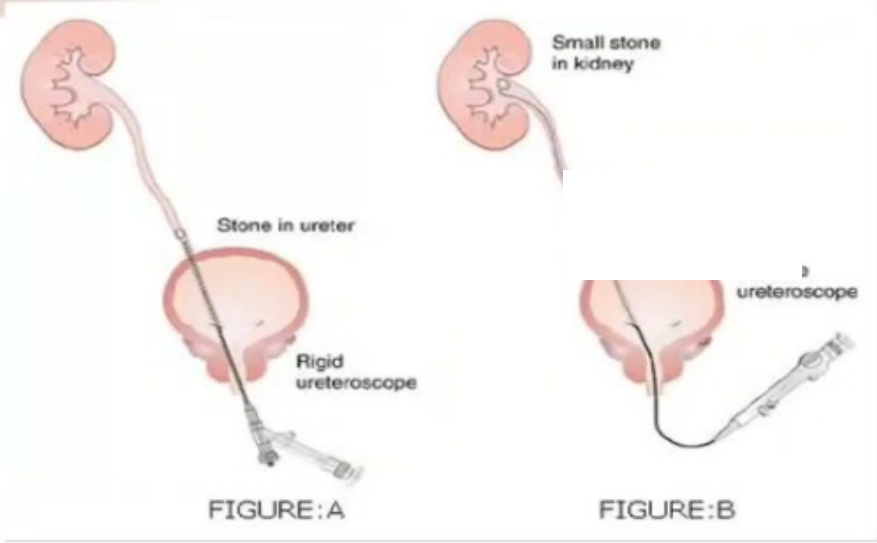
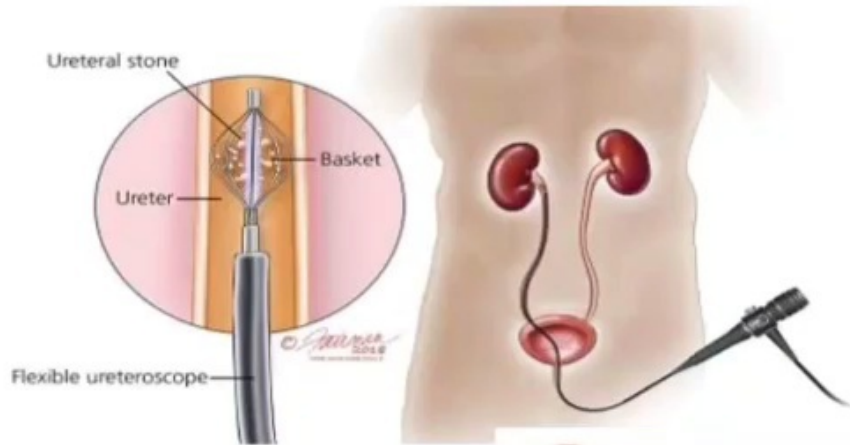
- **Semirigid URS:** for ureteral stones (mainly lower and mid ureter)
- **Flexible URS (f-URS):** allows navigation to upper ureter and kidney calyces
- **Energy Sources:**

Laser lithotripsy (Holmium:YAG or Thulium fiber laser) - gold standard

Pneumatic lithotripsy - less common



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Percutaneous Nephrolithotomy (PCNL)

A minimally invasive surgical procedure in which a percutaneous tract is created into the renal collecting system to allow removal of large or complex kidney stones using a nephroscope.

- Indications
- Renal stones >20 mm (first-line)
- Staghorn calculi (partial or complete)
- Stones resistant to ESWL / URS
- Anatomy unfavorable for ESWL or RIRS



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Percutaneous Nephrolithotomy (PCNL)

- Contraindications

Untreated urinary tract infection

Uncorrected coagulopathy

Severe cardiopulmonary instability (relative)

Pregnancy

Inability to safely access kidney percutaneously (rare anatomical variants)

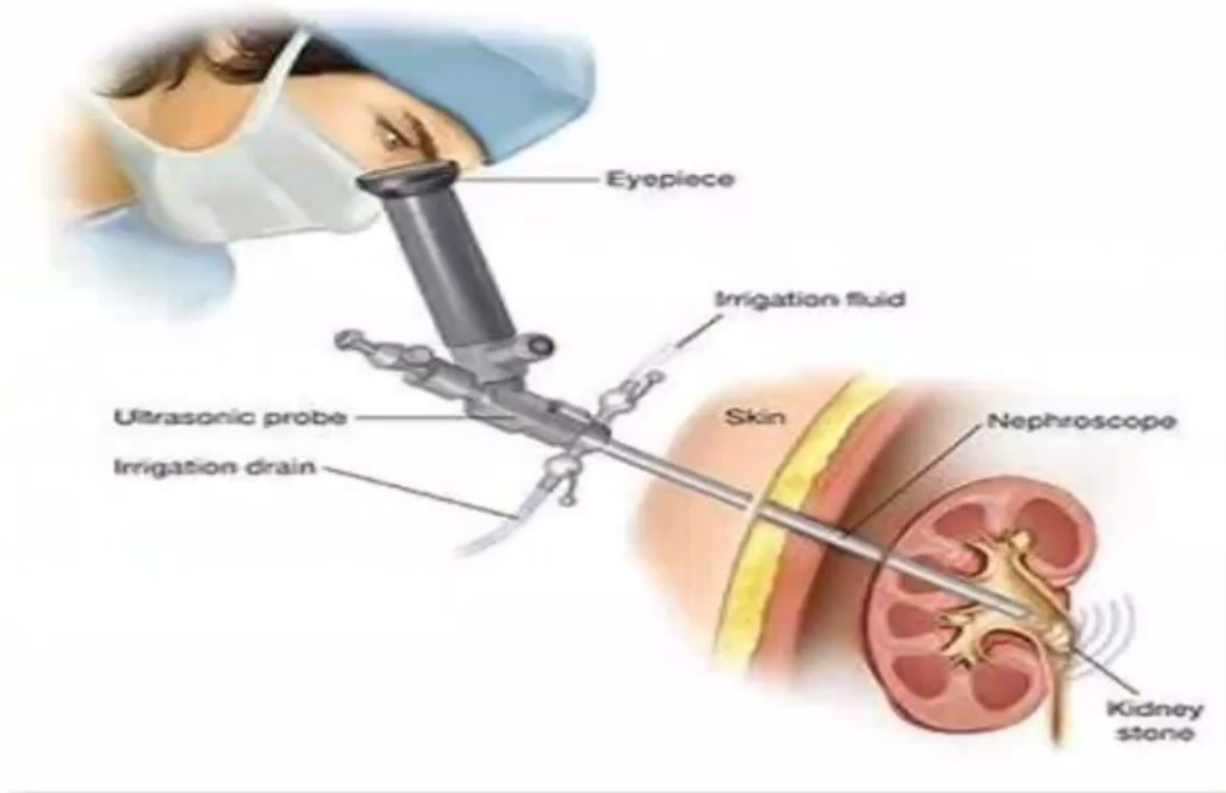


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Open Surgery



- **Laparoscopic or open stone removal (Pyelolithotomy/ureterolithotomy):**
- Indications:
 - complex stone burden: projection of stone into multiple calyces
 - Failure of endoscopic treatment
 - Difficulty performing endoscopic treatment due to anatomic renal abnormality, obesity, kyphoscoliosis
 - Nonfunctioning kidney

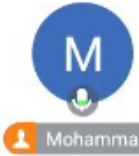


Factors Determining Definitive Stone Management

The choice of definitive treatment depends on multiple patient, stone, and anatomical factors.

Stone related factors

- Stone size
- Stone location
- Stone composition
 - Uric acid → dissolution therapy possible
 - Cystine / calcium oxalate monohydrate → harder stones → no ESWL → laser URS or PCNL
- Stone density (Hounsfield units)
- Stone visibility



Factors Determining Definitive Stone Management

Patient-Related Factors

- Presence of infection
- Body habitus
 - Obesity → ESWL technically difficult → URS/RIRS preferred
- Bleeding risk / anticoagulation

ESWL contraindicated

URS/RIRS preferred; PCNL avoided

- Pregnancy

ESWL contraindicated

URS safe in experienced hands



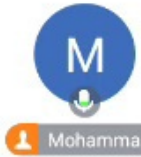
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Factors Determining Definitive Stone Management

Anatomical Factors

- **Infundibulopelvic angle, calyceal anatomy**
 - Poor lower pole drainage → ESWL failure → choose RIRS
- **Ureteral strictures**
 - May prevent URS access → need dilation or alternative approach
- **Urinary diversion (ileal conduit)**
 - Retrograde access difficult → antegrade PCNL/RIRS
- **Kidney anomalies**
 - Horseshoe kidney → ESWL less effective → RIRS/PCNL preferred



Case scenario

- A 52-year-old woman , known history of HTN , DM , atrial fibrillation on warfarin presents to the emergency department with severe right flank pain, fever, and vomiting for the past 24 hours.

- **Clinical examination**

Temp: 38.9°C, HR: 118 bpm, BP: 98/60, Right CVA tenderness

- **Laboratory results**

WBC: 17,200 / μ L, CRP: 112 mg/L, Creatinine: 2.1 mg/dL (baseline 1.0)

Urinalysis: pyuria, nitrite-positive

- **Imaging**

- CT- non contrasted shows:

A 2.5 cm staghorn-type stone

Moderate hydronephrosis

Perinephric fat stranding

No ureteric stones

Is there an indication for urgent intervention?

What are the definitive treatment options, and what treatments are contraindicated?