Stone disease

Mohammad Abufaraj

Associate 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.

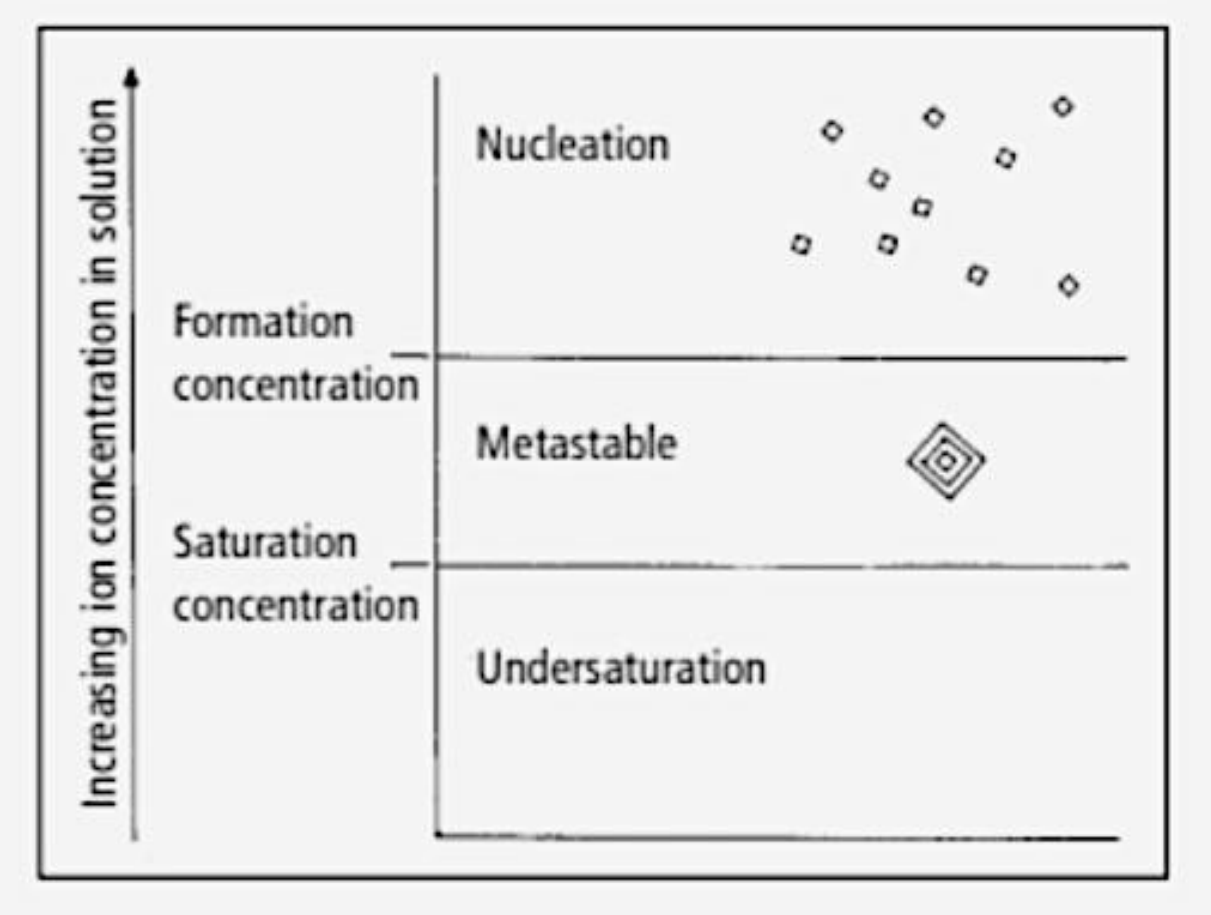
Risk Factors

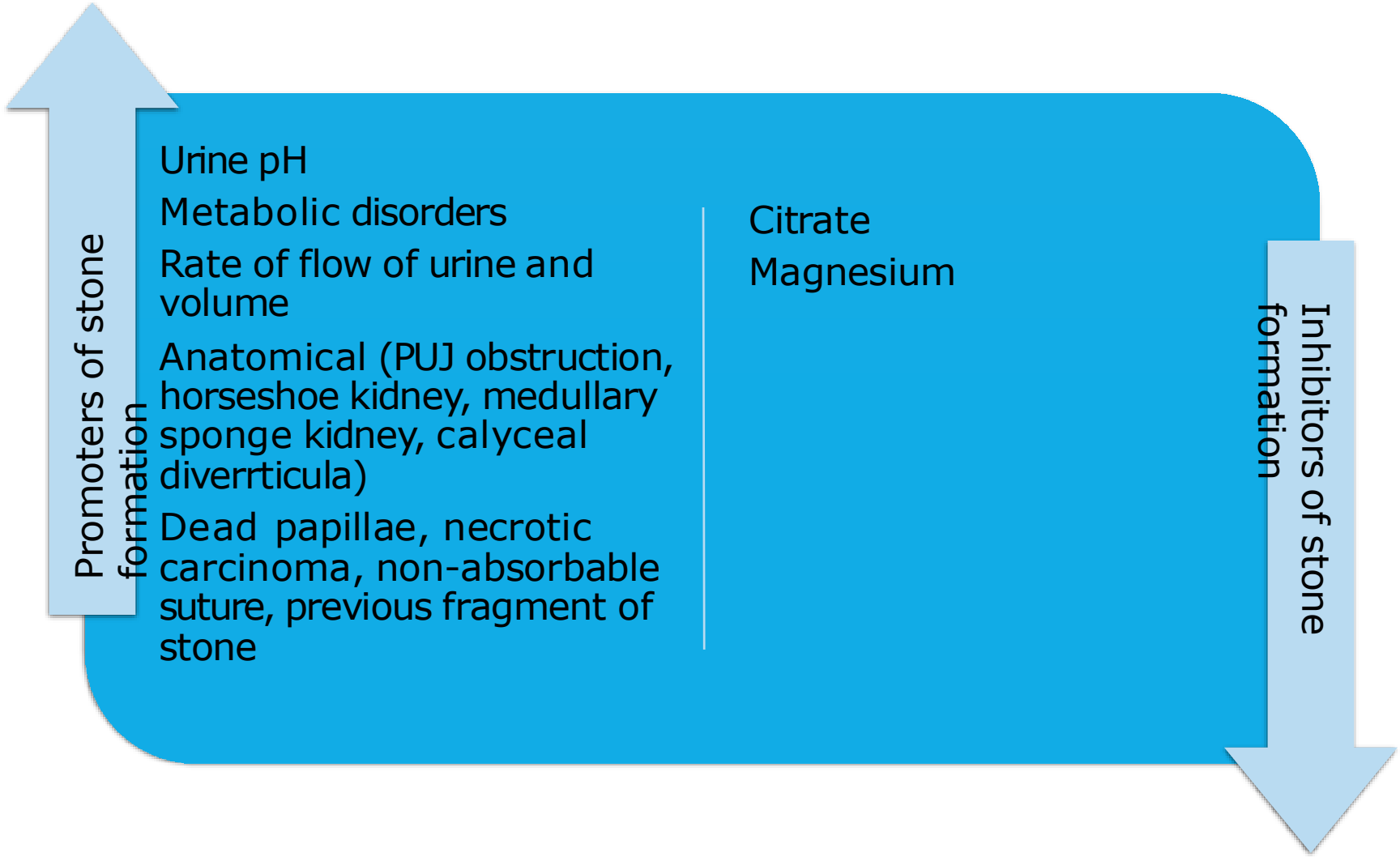
- A prior history of nephrolithiasis
- Family history of stones
- Stone disease is more common in individuals with diabetes, obesity, gout, and hypertension
- Low fluid intake and diet
- Malabsorption (gastric bypass, short bowel syndrome)
- Frequent upper urinary tract infections
- Use of medications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

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

Pathophysiology

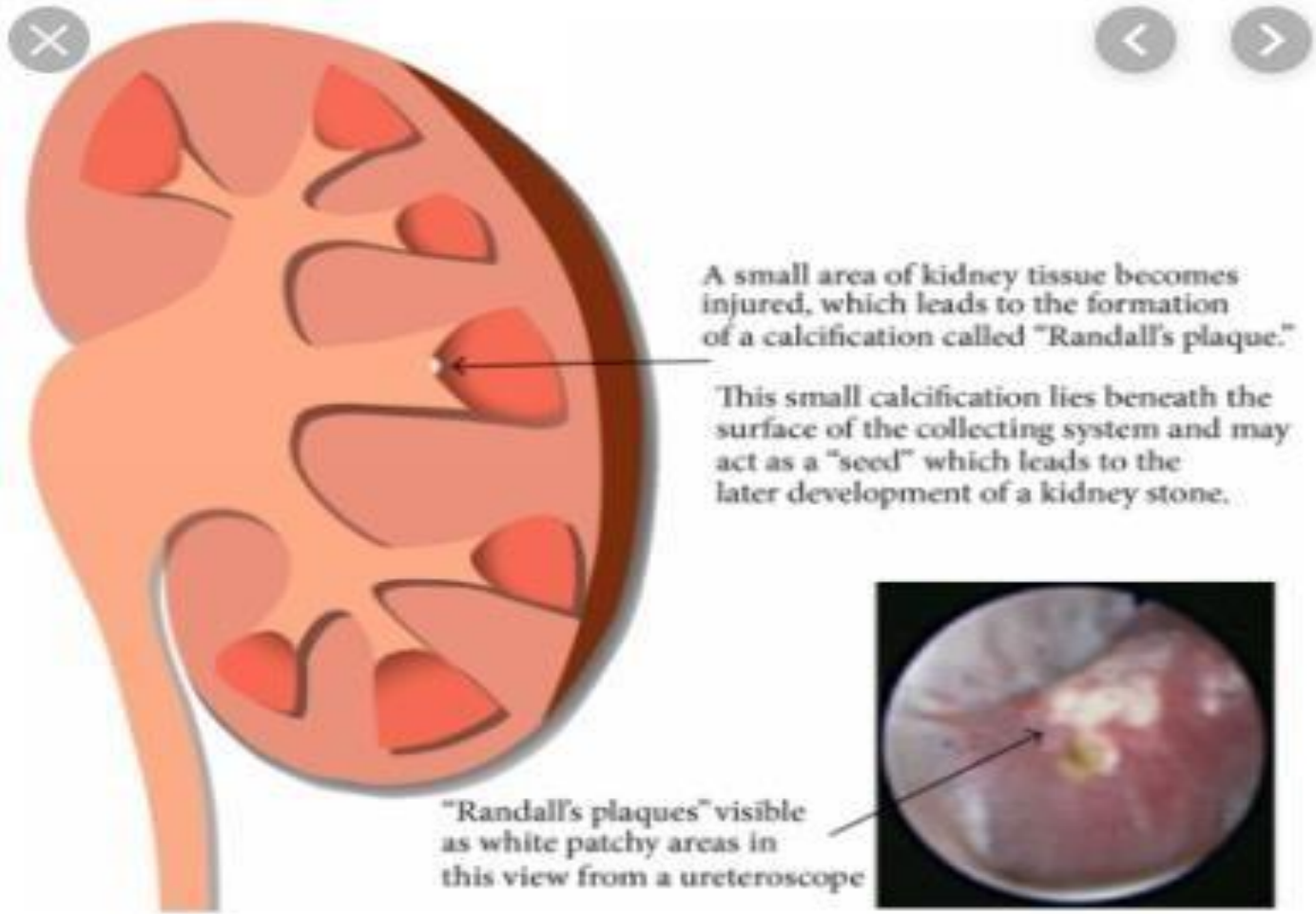
- Supersaturation
- Crystallization
- Growth




Promoters of stone formation
Urine pH
Metabolic disorders
Rate of flow of urine and volume
Anatomical (PUJ obstruction, horseshoe kidney, medullary sponge kidney, calyceal diverrticula)
Dead papillae, necrotic carcinoma, non-absorbable suture, previous fragment of stone
Citrate
Magnesium
Inhibitors of stone formation

Randall’s Plaques

- The first step in stone formation is the deposition of a plaque of calcium apatite on the beasement membrane of a renal tubule .
- The plaque grows within the renal parenchyma and erodes through the urothelium of renal papilla to act as a stable surface for the nucleation of superstaurated compounds in the urine.


A small area of kidney tissue becomes injured, which leads to the formation of a calcification called "Randall's plaque."
This small calcification lies beneath the surface of the collecting system and may act as a "seed" which leads to the later development of a kidney stone.
"Randall's plaques" visible as white patchy areas in this view from a ureteroscope

Classification

- Calcium Stones
- Oxalate Stones
- Uric Acid Stones
- Cystine Stones
- Struvite 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 due to :
- Hepatic Oxaluria
- Rare, autosomal recessive disorder of metabolism
- Enteric Oxaluria
- Most common, chronic diarrhea and fat malabsorption
- Dietary Oxaluria

Calcium oxalate crystals

- 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.

- 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

- Hexagon 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)

MINIMIZE START QUIZ

Types	Incidence	Etiology/associated findings	Urine pH	Crystal appearance	Radiopacity	Prophylaxis

Calcium oxalate stones	• ~ 75%	• Hypercalciuria
		• Hyperoxaluria
		• Hypocitraturia
		• Can result from increased intake of
		  ◦ Ethylene glycol (antifreeze)
		  ◦ Vitamin C
		• Associated with inflammatory bowel disease, i.e., ulcerative colitis and Crohn disease due to malabsorption
			• ↓ Urine pH (acidic)	• **Biconcave dumbbells** or **bipyramidal envelopes**	• Radiopaque	• Urine alkalinization

Uric acid stones	• ~ 10%	• Gout, hyperuricemia, and hyperuricosuria • High cell turnover (e.g., leukemia, chemotherapy)	• ↓ Urine pH (acidic) and volume (often seen in desert climates)	• Rounded rhomboids, rosettes, or **needle-shaped**	• Radiolucent	• Urine alkalinization
Struvite stones	• ~ 5–10%	• UTI with urease-producing bacteria (e.g., *Proteus mirabilis*, *S. saprophyticus*, *Klebsiella*)	• ↑ Urine pH (alcalic)	• Rectangular prisms (**coffin lid-appearance**)	• Weakly radiopaque	• Urine acidification
Calcium phosphate stones	• < 5%	• Hyperparathyroidism • Type 1 renal tubular acidosis	• ↑ Urine pH (alcalic)	• **Wedge-shaped prisms**	• Radiopaque	• Urine acidification
Cystine stones		• Cystinuria (hereditary)	• ↓ Urine pH (acidic)	• **Hexagon-shaped**	• Weakly radiopaque	• Urine alkalinization
Xanthine stones		• Xanthinuria (hereditary)	• Generally independent of urine pH	• Amorphous	• Radiolucent	• 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

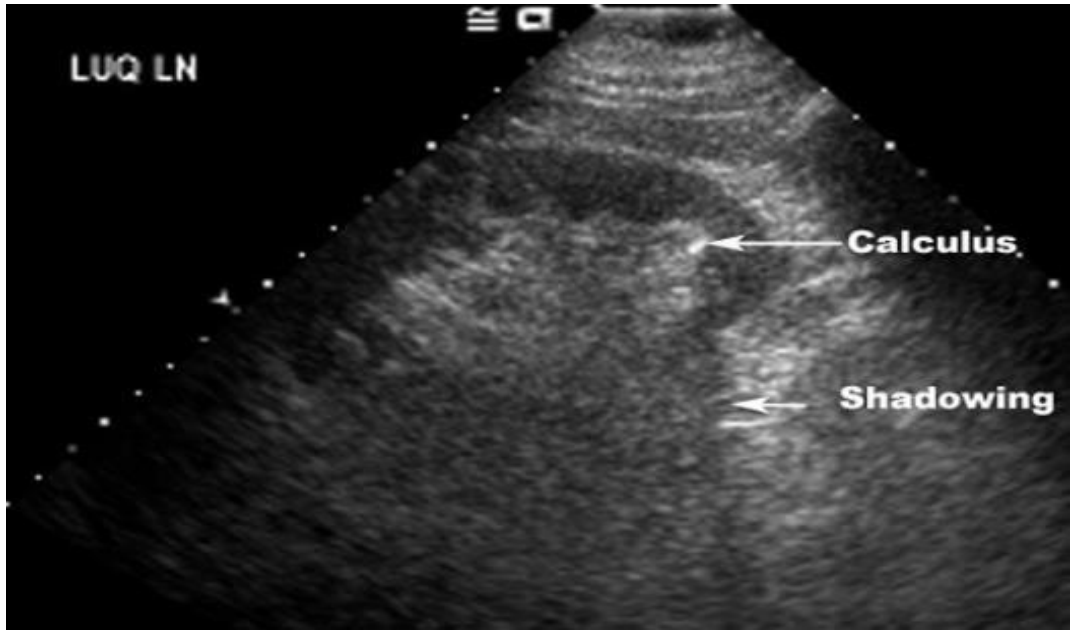
- Urine analysis and culture
- Metabolic workup (calcium, uric acid, creatinine, urea)
- Any stone should be analyzed by x-ray crystallograhy.
- CBC
- KFT

- **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

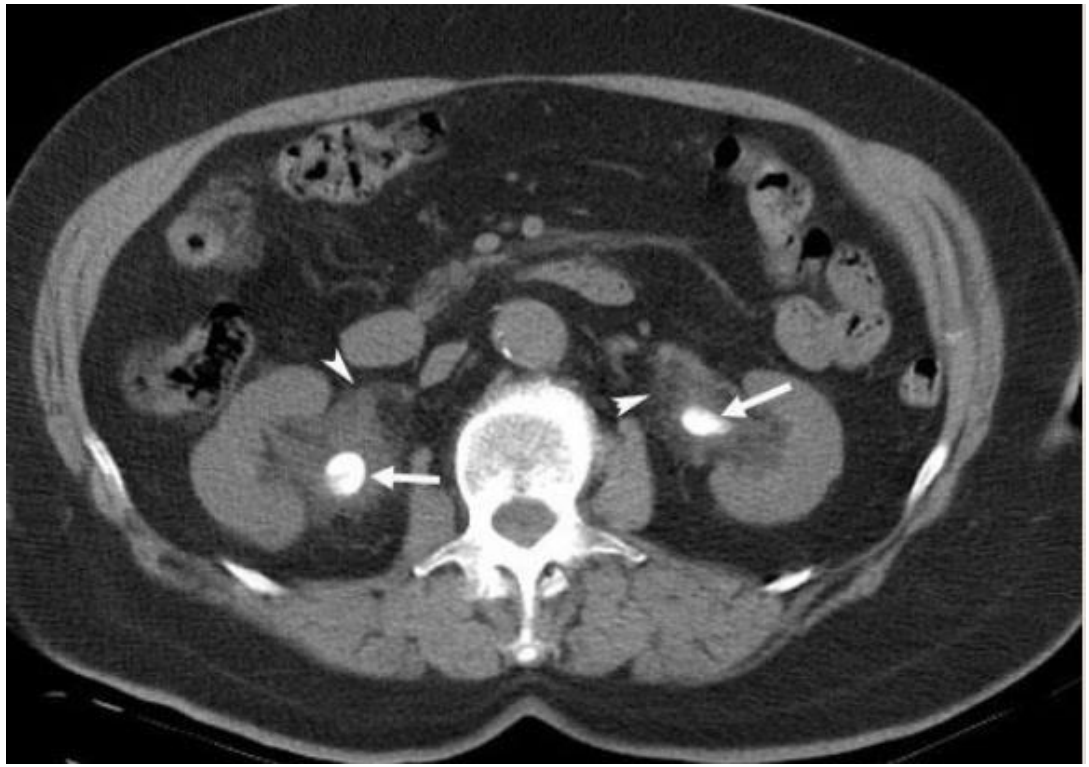
Imaging Studies

- **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



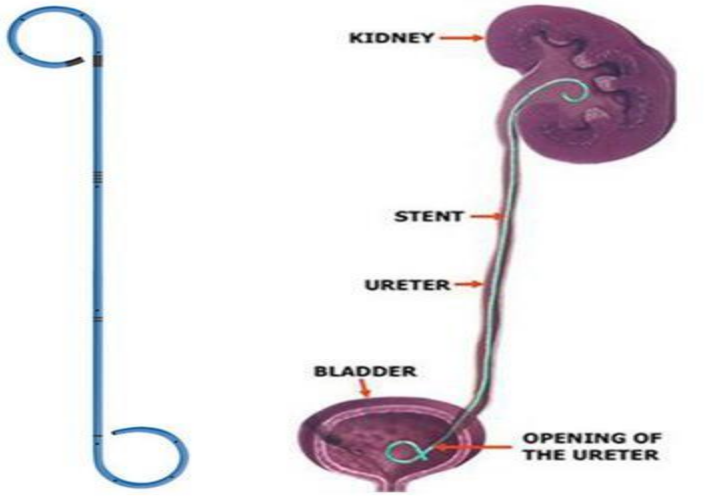
Acute Management of Renal Colic

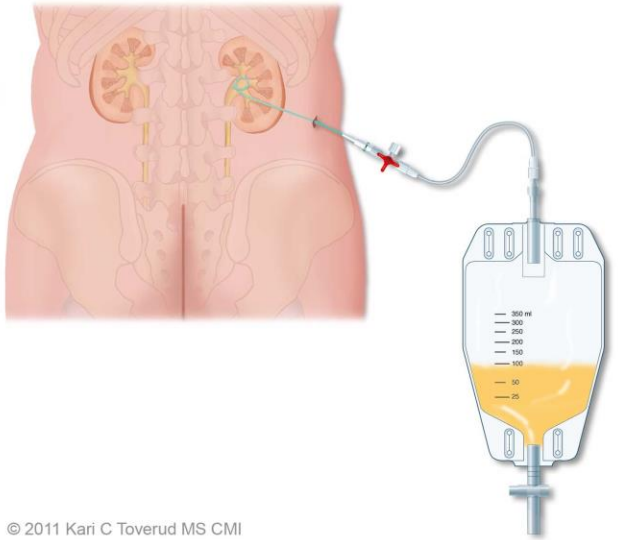
- **Definition:**
  Renal colic is acute flank pain caused by obstruction of the ureter, leading to increased renal pelvic pressure and prostaglandin-mediated ureteric spasm.
- **Acute Management Steps:**
- Rapid assessment of hemodynamic status
- Analgesia (NSAIDs first-line; opioids if refractory)
- Hydration (avoid excessive IV fluids; goal is euvolemia)
- Antiemetics if needed
- Rule out complications (infection, obstruction, acute kidney injury)
- Initial imaging (non-contrast CT preferred; ultrasound)

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

- **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





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)

- **Definition:**
  Use of pharmacologic agents to facilitate spontaneous stone passage by reducing ureteral spasm and edema.
- **Indications:**

Ureteric stones ≤**10 mm**, particularly in the **distal ureter**

Stable patient with no indication for urgent decompression

No infection, no uncontrolled pain

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%)

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

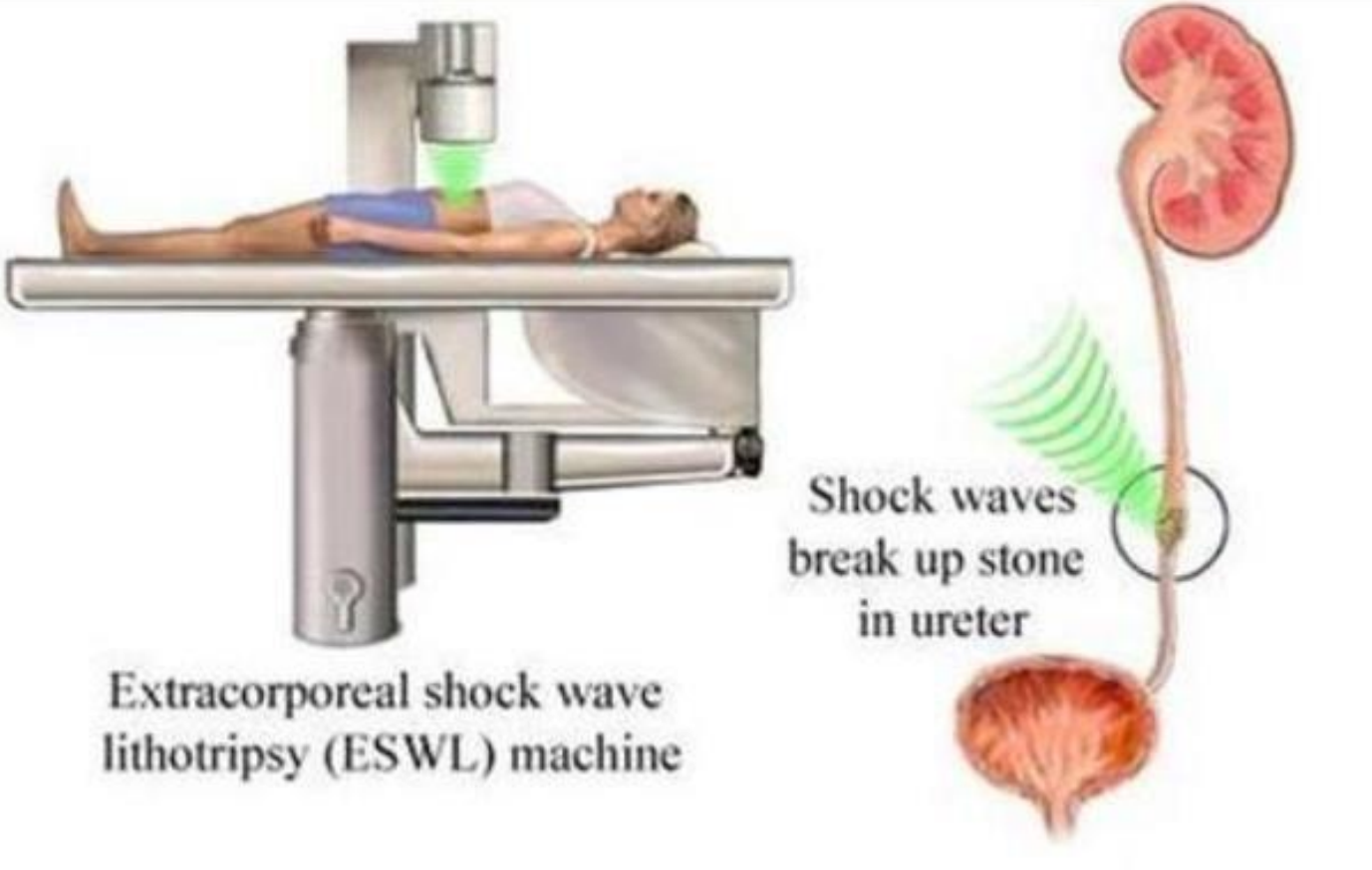
Active UTI

Uncorrected coagulopathy

Severe skeletal deformities preventing positioning

Aortic aneurysm in shock-wave path

Morbid Obesity preventing targeting (machine-dependent)


Shock waves
break up stone
in ureter
Extracorporeal shock wave
lithotripsy (ESWL) machine

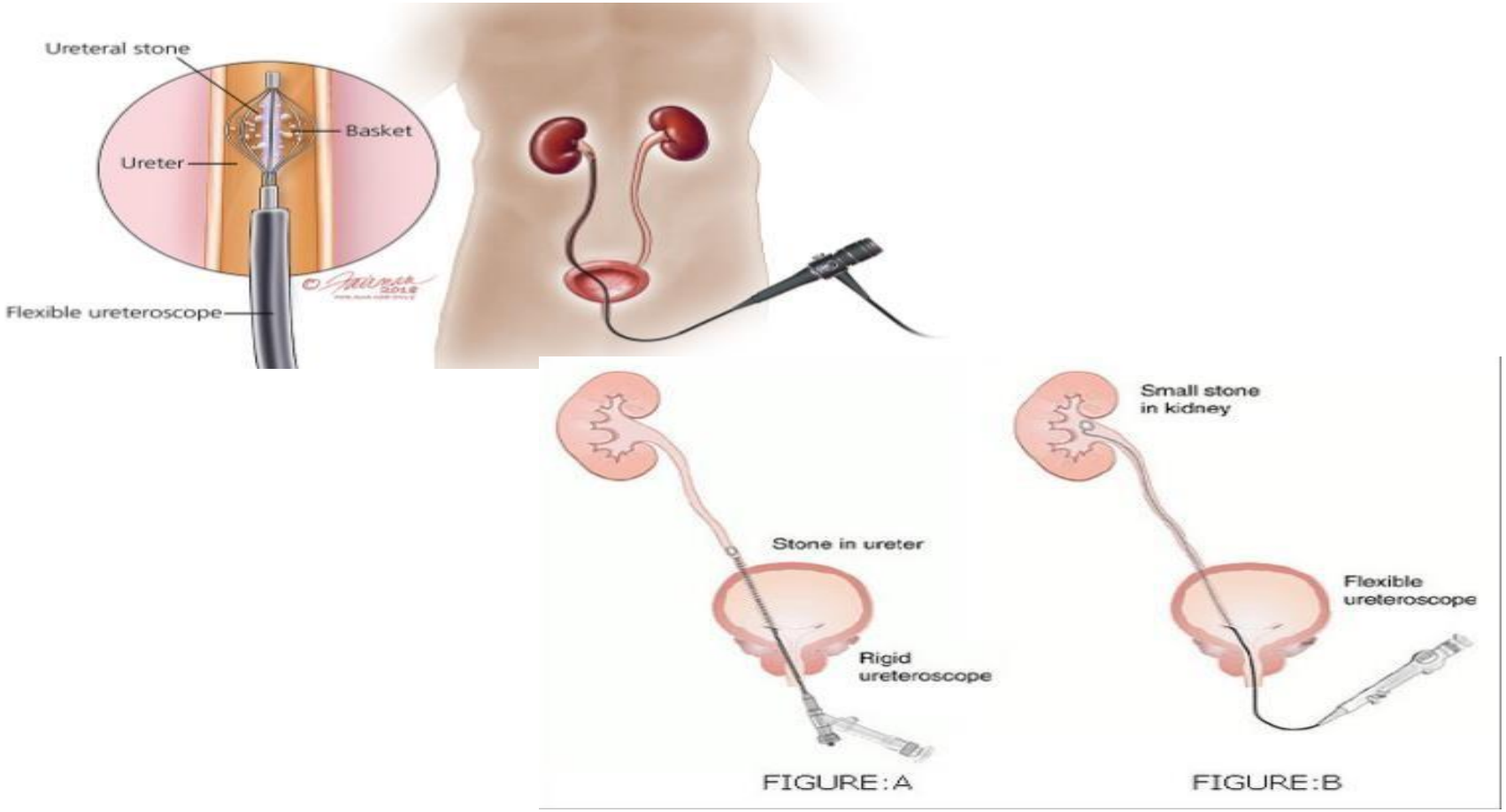
RIRS (Retrograde Intrarenal Surgery)

- **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

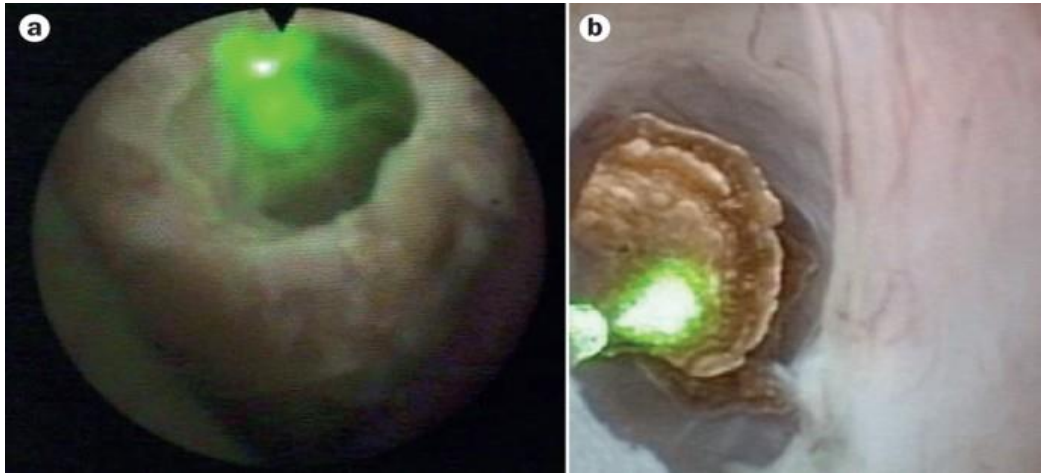


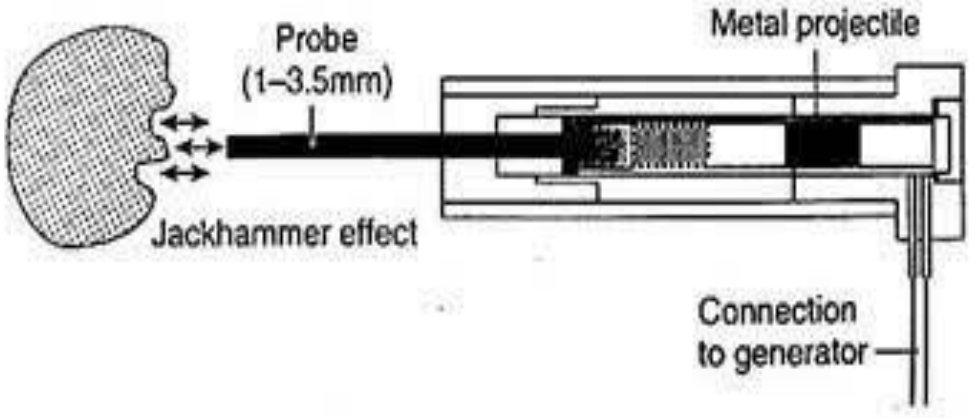
Retrograde intrarenal surgery

- **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



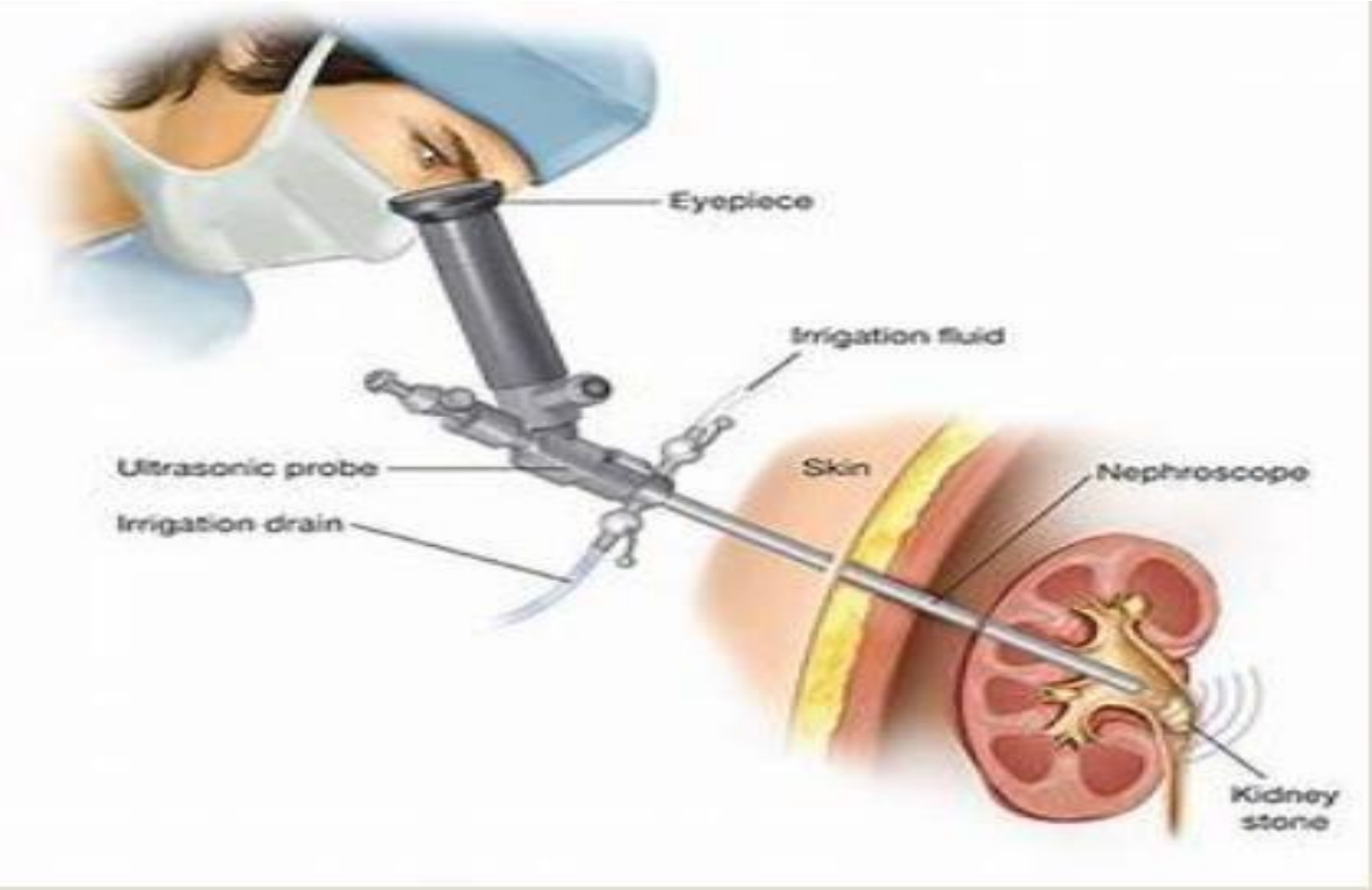


Percutaneous Nephrolithotomy (PCNL)

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**

Percutaneous Nephrolithotomy (PCNL)



Percutaneous Nephrolithotomy (PCNL)

- **Contraindications**

Untreated urinary tract infection

Uncorrected coagulopathy

Severe cardiopulmonary instability (relative)

Pregnancy

Inability to safely access kidney percutaneously (rare anatomical variants)

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

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 /µL,** 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

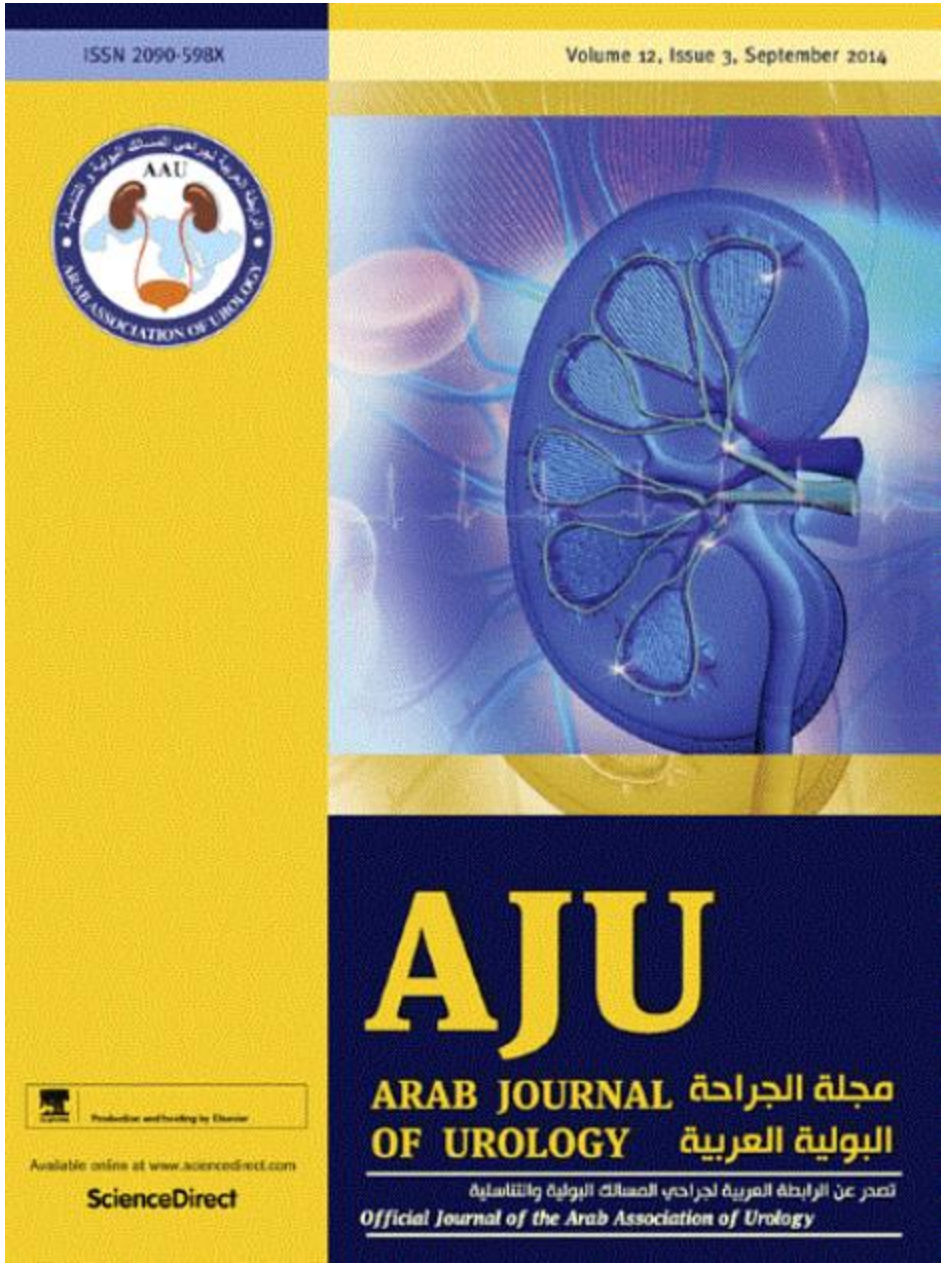
Perinephric fat stranding

No ureteric stones

Is there an indication for urgent intervention?

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

Thank you


ISSN 2090-598X
Volume 12, Issue 3, September 2014
AAU
AJU
ARAB JOURNAL مجلة الجراحة
OF UROLOGY البولية العربية
Official Journal of the Arab Association of Urology
ScienceDirect