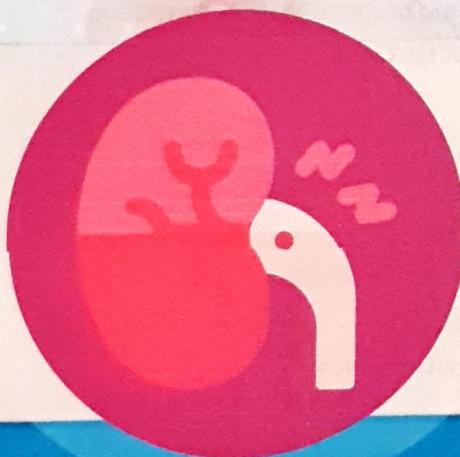


UROLOGY

Level 4 – Semester 7



Lecture 2 Urolithiasis (Urinary Stones)

Dr/ Ahmed Kamel



Urolithiasis (Urinary Stones)



Epidemiology

Incidence:

- Urinary calculous disease is a common disorder.
- The lifetime risk is about **10 to 15%**.

Sex:



>



Age:

Occur mainly in **middle age group**, but **no age is exceptional**.

Areas:

More common in people living in mountains, deserts and tropical areas. مطروح - سيناء

Genetic:

Cystinuria and familial RTA (Ca Phosphate stones).



Etiology

Risk Factors:

- 1- **Dehydration** from **low fluid intake (poor drinking)** is a major factor in stone formation.
- 2- **High dietary intake of Animal protein - Added Salt (NaCl) - Oxalate**
- 3- **Urine stasis:**
 - A fair rate of urine flow would expel crystals before they have the chance to coalesce and grow.
 - **Examples for stasis:** BPH (SPE), Neurogenic bladder.



BPH: Benign Prostatic Hyperplasia | BPH: Benign Prostatic Hyperplasia

4- Urinary Tract Infection:

- Stones associated with **chronic UTI** are called "**Struvite stones**".

5- Metabolic Disorders, e.g.:

- Renal tubular acidosis.
- Gout.
- Cystinuria.





Pathophysiology

Mechanisms of stone formation:

①	Saturation	◆ Concentration product > solubility product.
②	Supersaturation (Formation product)	◆ The urine becomes supersaturated with one or more calculogenic (crystal-forming) substances e.g.: ↳ Hypercalciuria, Hyperuricosuria, Hyperoxaluria.
③	Nucleation	◆ Definition: A crystal or a foreign body in supersaturated urine can act as a solid surface on which a crystal can grow.
④	Cementation (Matrix formation)	◆ Definition: An organic matrix of serum and urinary proteins provides a framework for deposition of crystals.
⑤	Crystallization	◆ Process: Formation of crystals then aggregate together. ◆ Normally.. this process inhibited by crystal inhibitors e.g., ✓ Citrates → inhibit calcium. ✓ Magnesium → inhibit oxalate. ◆ Absence or low concentration of normal urinary inhibitors → Permits crystallization.
⑥	Stone Growth (Epitaxy)	◆ Over-growth of the stone by deposition of one crystal on the surface of another.



Types of Stones

1- Calcium containing stones:

A. Calcium oxalate: most common type of calculi, 2 types:

- ◆ Calcium oxalate monohydrate (COM)
- ◆ Calcium oxalate dihydrate (COD)

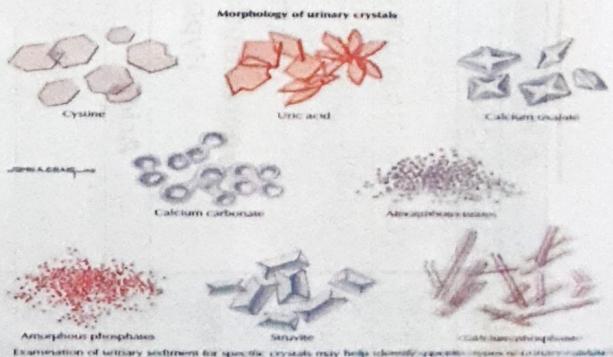
B. Calcium Phosphate.

2- Struvite Stones (Infection stones or triple-phosphate stones).

3- Uric acid Stones.

4- Cystine Stones.

5- Xanthine Stones & Other rare types.



Urology

L2: Urolithiasis



MCQ

① Calcium containing stones

Calcium Oxalate Calcium Phosphate

70%-80% of all cases.

(Ca Oxalate is the commonest UT Stones)

Typically contain Ca oxalate either alone or with Ca phosphate.

Hypercalciuria – Hyperoxaluria - Hypocitraturia.

Alkaline

Small or moderate

Radio-opaque



NB & Fig.

② Struvite Stones

10 – 15 %

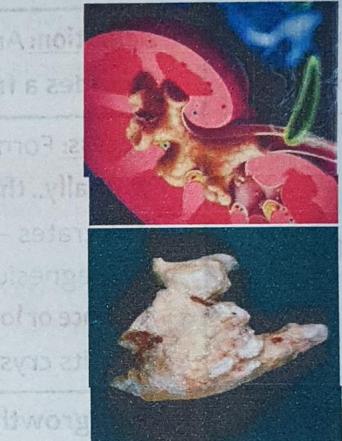
Ammonium, Magnesium, Phosphate ($\text{NH}_4 \text{MgPO}_4 \cdot \text{H}_2\text{O}$)

Due to infection by urea-splitting bacteria e.g., proteus, Klebsiella, pseudomonas.

Acidic

Small

Radio-opaque



(the only radiolucent stone)

③ Uric acid stones

5 – 10 %

Uric acid

Caused by Hyperuricosuria



◆ NB:

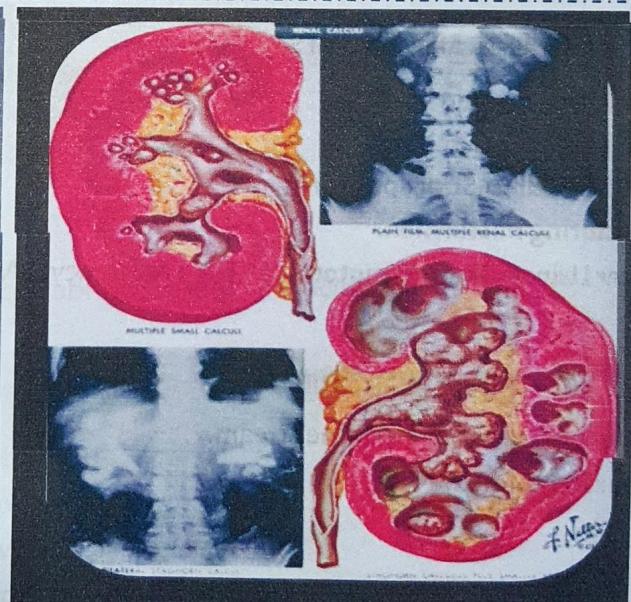
- It's more common in **obese diabetic patients**.

- The only stone that can be treated with **oral dissolution therapy**.

* الحالات المظليلة إضافة لـ **كمال الجدول** *

MCQ

	④ Cystine stones	⑤ Xanthine stones
Incidence	1 - 3 % "Usually appears in young patients (children)"	Extremely Rare
Etiology	Associated with hereditary cystinuria <ul style="list-style-type: none"> ◆ Autosomal Recessive disease. ◆ Results from defect in transmembrane cysteine transport in PCT. ◆ Leads to accumulation of non-soluble cystine molecules in urine. 	Associated with hereditary xanthinuria
pH of urine	Acidic	Acidic
X-ray	Faint Radio-opaque	Pure xanthine stones are radiolucent , but approximately 1/3 of patients with xanthinuria there may be a calcium salt mixture to render these stones slightly radio-opaque .
Fig.		



Staghorn Stone

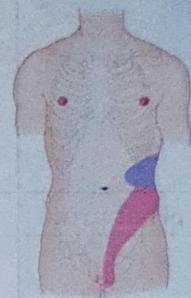




Clinical Presentation

01 C/P OF RENAL STONES

①	Asymptomatic	Incidentally discovered
②	Symptomatic	<p>1) Renal colic.</p> <ul style="list-style-type: none"> ◆ Nature: Acute, Intermittent, Severe colicky pain. ◆ Site: Felt in the loin (flank), radiating to the groin. ◆ Associated with: nausea & vomiting. ◆ Not related to: activity, position, or meal. ◆ Relieved by: analgesics. <p>2) Microscopic hematuria.</p> <p>3) Urinary tract infection.</p> <p>4) Burning Micturition.</p>
③	Complications	Symptoms of complications



02 C/P OF URETERIC STONES

● Presentation of ureteric stones depends on site of the stone:

- ◆ **Upper 1/3 of the ureter:** like Acute renal colic.
- ◆ **Middle 1/3 of the ureter:** Colicky pain in the iliac fossa.
- ◆ **Lower 1/3 of the ureter:** like Bladder calculi.

03 C/P OF BLADDER STONES

- 1) Pain.
 - ◆ **Nature:** Dull aching.
 - ◆ **Site:** Felt in Suprapubic region.
- 2) Pain during micturition.
- 3) **Lower Urinary Tract Symptoms (LUTS):** Frequency, BM.

04 C/P OF URETHRAL STONES

- 1) Sudden interruptions of urine stream.
- 2) Urinary retention.



**Complications**

1	Obstruction	◆ The effects of obstruction depend on the site of the stone: ◆ Hydronephrosis (renal and ureteric stones). ◆ Urinary retention (urethral and bladder stones).
2	Urinary Tract Infection	Stasis encourage infection.
3	Deterioration of renal function	◆ Either obstruction or infection affects the renal function. ◆ Acute Kidney Injury (AKI) may occur due to bilateral obstruction
4	Metaplasia of the urinary epithelium (urothelium)	◆ Chronic irritation of the transitional epithelium caused by friction by the stone, either in the renal pelvis or the urinary bladder causes squamous metaplasia. ◆ Further irritation is thought to lead to squamous cell carcinoma.

**Diagnostics****● Laboratory investigations:****1) Urine analysis:**

- ◆ Microscopic hematuria (RBCs > 5/HPF).
- ◆ Pyuria: (WBCs > 5/HPF).
- ◆ Bacteriuria: (in UTI).
- ◆ Presence of Nitrites in urine → indicates bacteriuria.
- ◆ Crystalluria: Calcium Oxalate, Uric Acid, Cystine.
- ◆ Changes in Urine pH: (Acidic in uric acid stones, alkaline in struvite stones).

2) Urine Culture: If urine analysis showed pyuria or bacteriuria.**3) Blood tests:**

- ◆ Serum creatinine, CBC
- ◆ Detection of underlying metabolic abnormalities (uric acid).

4) Stone analysis.**● Radiological Investigations:**

- 1) X-Ray film of Kidney-Ureter and Bladder (KUB).
- 2) Abdominal and Pelvic Ultrasonography.
- 3) Intravenous urography "IVU" (Intravenous pyelography "IVP").
- 4) Spiral CT (Non-Contrast CT of the abdomen and pelvis) **The Most sensitive**
- 5) Diuretic renogram.



01 KIDNEY, URETER & BLADDER (KUB) X-RAY

◆ Causes of radio-opaque shadow in the hypochondrium:

- 1) Renal stone: 90% of the stones are radio-opaque.
- 2) G.B stones:
 - ♦ 10% of G.B. stones are radio opaque.
 - ♦ Usually multiple, faceted with signet ring appearance.

How to differentiate? With A lateral view film: *إضافة*



Renal Stone	G.B. Stone
Will be seen overlying the vertebral body	Lie anterior to the bodies of vertebrae

3) Calcified lymph nodes.

◆ Causes of radio-opaque shadow along the course of the ureter:

- 1) Ureteral stone.
- 2) Phleboliths:
 - ♦ Calcified thrombi in the pelvic veins that simulate the appearance of ureteric pelvic stones.
 - ♦ But commonly have radiolucent centers.
- 3) Calcified lymph nodes.



02 ULTRASOUND

Information from Renal US:

- Kidney site, size.
- Grade of hydronephrosis, Cortical thickening.
- Cortico-medullary differentiation.
- Detection of Renal stones, cysts, tumors, perinephric collections.

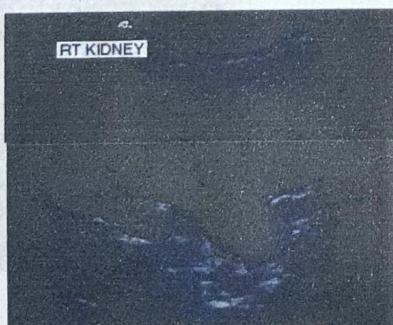
Findings:

- Renal stones appear as **Hyper-echoic (white)** are **with posterior acoustic shadow (black)**.



NB:

- Ureteric stones may not be seen by US but the hydronephrosis resulting from obstruction is seen.
- **US is Operator dependent.**



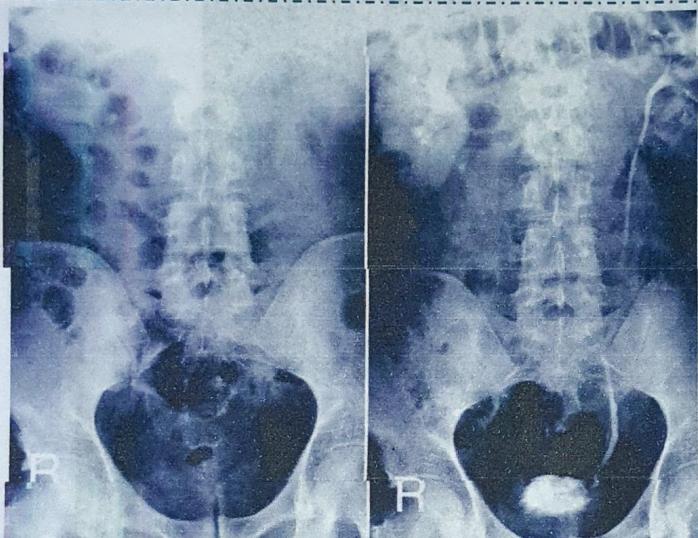
03 INTRAVENOUS PYELOGRAM (IVP)

Advantages:

- 1) Visualization of the pelvi-calyceal, ureteric and bladder anatomy.
- 2) Give an idea about renal function.

Disadvantages:

- 1) Needs preparation.
- 2) Complications of iodinated contrast such as anaphylaxis and contrast nephropathy.



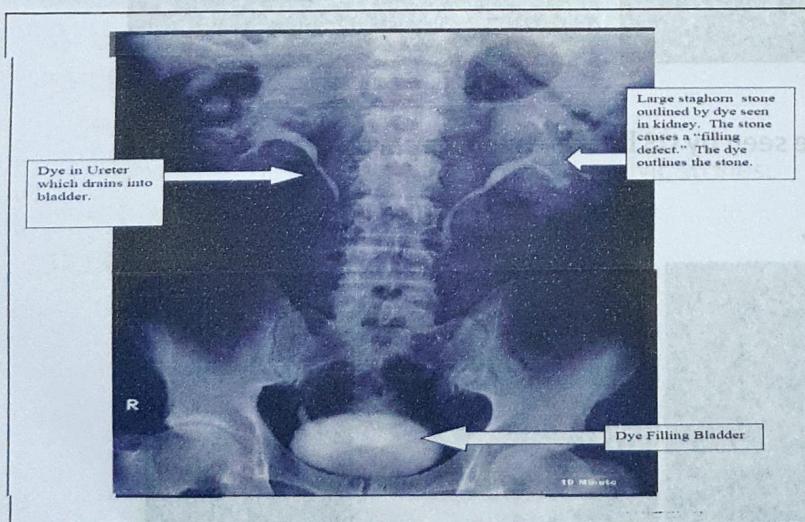
((AP view; left: pre-contrast; right: 2.5 hours post-contrast)

Excretory urography showing Obstructing ureteral calculus *اضطراب*



- **UC; red overlay:** Ureteral calculus.
- **Green overlay:** The right kidney is enlarged, with persistent enhancement.
- **Region indicated by dashed lines:** There is pelvicaliectasis & poor contrast-filling of the right ureter.
- **Blue overlay:** The left renal collecting system is normal.

Source: © IMPP, Amboss



04 NON-CONTRAST CT (NCCT)

The most sensitive investigation in detection of urinary calculi.

◆ Advantages:

- 1) No need for bowel preparation.
- 2) No need for contrast injection.
- 3) More sensitive than KUB and US for detection of calculi.
- 4) Can detect radio-opaque and radio-lucent stones.
- 5) Perirenal and periureteral anatomy is seen.
- 6) Images can be in multiple formats (axial, coronal, sagittal).

◆ Disadvantages:

Radiation exposure.

◆ Findings:

- ◆ Stones appear as hyperdense (white) area.





Management

العلاج يتضمن لكل حالة حسب ما يناسبها، وده يبيحدده عدة عوامل

- ◆ **Patient factors:** Age, Pregnancy, obesity, co-morbidities ... etc.
- ◆ **Renal factors:** function, anomalies , recurrence , pcs anatomy ... etc.
- ◆ **Stone factor:** Size, multiplicity, site, composition ... etc.
- ◆ **Hospital factor:** modality availability

I

TREATMENT OF ACUTE RENAL COLIC

● Medical:

①	Analgesics	<ul style="list-style-type: none"> ◆ Non-steroidal Anti-inflammatory Drugs (NSAIDs): <ul style="list-style-type: none"> ◆ They are the first choice unless there is a contraindication. ◆ Route: IV, IM, or PR. ◆ Paracetamol: IV Injection. ◆ Opioids: If pain persisted despite using other analgesics.
②	Anti-emetics	if there is vomiting
③	Antibiotics	if there is evidence of infection



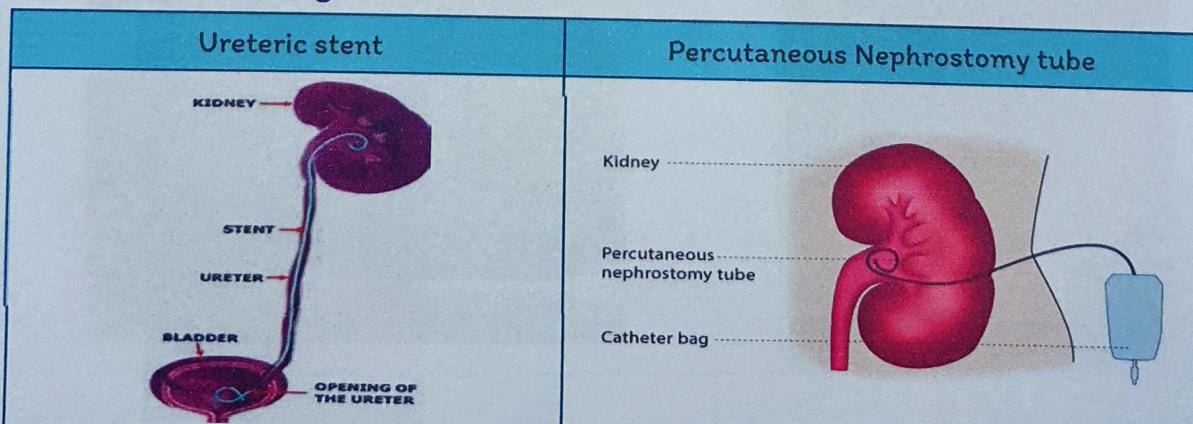
No role for antispasmodics or forced diuresis.

● Renal Drainage:

◆ Indications for emergency drainage of the obstructed kidney:

- 1) Fever, sepsis, or septic shock.
- 2) AKI (high serum creatinine).
- 3) Anuria.
- 4) Leukocytosis.
- 5) Intractable pain despite opioids.

◆ Methods for renal drainage:



II

TREATMENT OF RENAL STONES

❖ Treatment of Renal Stones maybe:

- 1) Conservative.
- 2) Instrumental:
 - ♦ Extracorporeal Shockwaves Lithotripsy (ESWL).
 - ♦ Flexible Ureteroscopy.
 - ♦ Percutaneous Nephrolithotomy (PCNL).
- 3) Surgical:
 - ♦ Laparoscopic or Open surgery.

● Conservative Treatment & Follow up:

❖ Indications:

- ♦ For incidentally discovered calyceal stones <5 mm, not causing infection, obstruction, or hematuria.
- ❖ Follow-up: by ultrasonography, every 3 months.

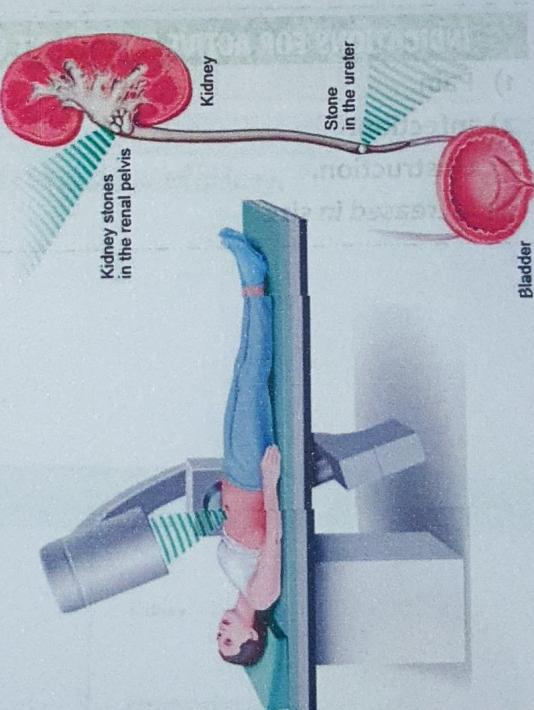
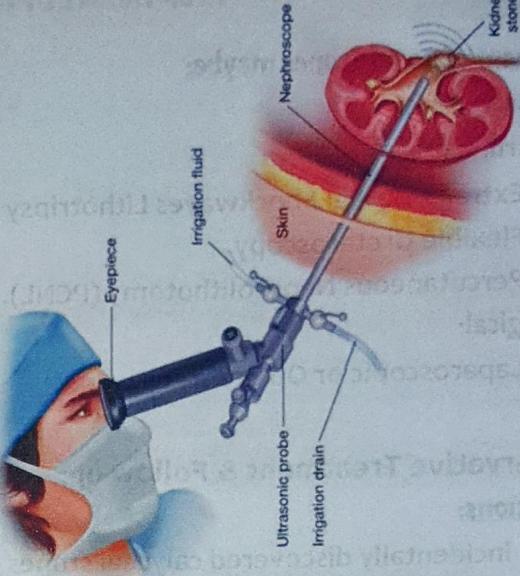
INDICATIONS FOR ACTIVE TREATMENT OF RENAL STONES

- 1) Pain.
- 2) Infection.
- 3) Obstruction.
- 4) Increased in size.



● Instrumental management:

1.2 ESWL & PCNL

Extracorporeal Shock Wave Lithotripsy (ESWL)	Percutaneous Nephrolithotomy (PCNL)
<ul style="list-style-type: none"> To generate shock waves outside the body and Transmission of these waves to inside guided by using X-ray or ultrasonic imaging. The stone will be fragmented → Then the fragments pass spontaneously. 	<ul style="list-style-type: none"> To create a track from the skin to the pelvicalyceal system under fluoroscopic or ultrasound control. The track is then dilated to accommodate the nephroscope. Then the stone is removed through the sheath either: <ul style="list-style-type: none"> Mechanically: removed by forceps (if it is small). OR after disintegration by using electrohydraulic, laser or ultrasound lithotripsy (if it large).  

The Idea

**Extracorporeal Shock Wave Lithotripsy (ESWL)****Percutaneous Nephrolithotomy (PCNL)****Stone Size:**

- ◆ < 20 mm in any site of kidney except lower calyx.
- ◆ < 10 mm in the lower calyx.

1. Large stones (> 20 mm).
2. Hard stones (Cystine, COM).
3. Failure of ESWL.
4. Staghorn stones.

Advantages over open surgery:

- ◆ It is **noninvasive** technique which can be done as **outpatient procedure without anesthesia**.
- ◆ The success rates are **less than** other invasive treatment modalities.

Contraindications

1. Uncorrected bleeding disorders (coagulopathy).
2. Uncorrected hypertension.
3. Untreated urinary tract infection.
4. Pregnancy.
5. Distal obstruction.

Complications

1. Hard stones: CT density > 1000 HU.
2. Morbid obesity

1. Transient attacks of hematuria.
2. Residual fragments.
3. Urinary tract infection (due to destruction of the stone & release of bacteria inside the stone into the pelvicalyceal system).

4. Urinary tract obstruction by stone fragments.

1. Uncorrected coagulation disorder (the main contraindication, for fear of bleeding).
2. Uncontrolled hypertension (for fear of bleeding).
3. Untreated urinary tract infection (for fear of septicemia).
4. Urinary T.B.

1. Bleeding (the most common complication).
2. Injury of adjacent organs: e.g., colon, spleen, pleura, liver.
3. Residual stones.
4. Extravasation of irrigating fluid into retroperitoneum or peritoneal cavity → **Septicemia**.



NOTES ON ESWL (إضافة)

ESWL-responsive Stones

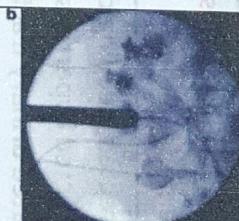
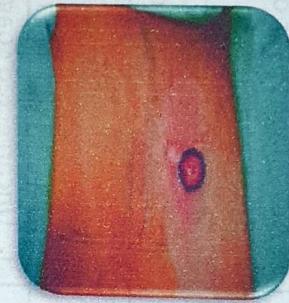
(Fragile stone, more successfully fragmented with ESWL)

- Calcium oxalate dihydrate (The most Fragile stone).
- Uric acid.
- Struvite.

ESWL-resistant stones

(Hard Stones; difficult to be fragmented with ESWL)

- Cystine (The most hard stone).
- Calcium oxalate monohydrate (COM).
- Brushite (Calcium phosphate stones).



Percutaneous Nephrolithotomy (PCNL)

03 FLEXIBLE URETEROSCOPY (URS)

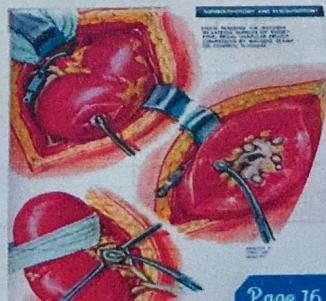
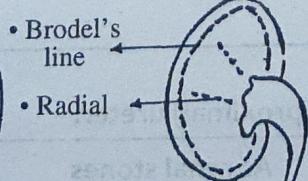
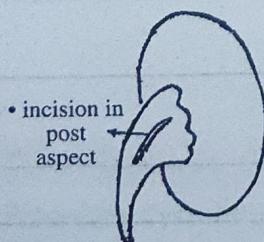
Procedure	<ol style="list-style-type: none"> 1) Reach the renal stones through the urethra, bladder, and ureter. 2) Disintegrate the stone using Laser. 3) Then fragments can be removed by a basket. 
Indications	Renal stones < 20 mm at any site
Advantages	<ul style="list-style-type: none"> • Can be used for any stone type (hard or not). • Can be used in: <ul style="list-style-type: none"> ✓ Patients with coagulation disorders. ✓ Morbidly obese patients. • Success rates are better than ESWL.
Disadvantages	<ul style="list-style-type: none"> • Expensive instruments (flexible URS, Laser, Basket). • Needs experienced surgeon.

● Surgery:

01 OPEN SURGERY

❖ The possible operations include: *الشجاع إضافة*

①	Pyelolithotomy	Opening the renal pelvis and removal of the stone.
②	Nephrolithotomy	Incision through the renal parenchyma.
③	Pyelonephrolithotomy	Combining the above mentioned two procedures.
④	Lower polar partial nephrectomy	In stones obstructing neck of lower calyx with thinning of its parenchyma.
⑤	Nephrectomy	If the kidney is nonfunctioning.



TREATMENT OF URETERIC CALCULI

❖ **Treatment of Ureteric Stones maybe:**

- 1) Conservative.
- 2) Medical Expulsive Therapy (MET).
- 3) Instrumental:
 - ♦ Extracorporeal Shockwaves Lithotripsy (ESWL).
 - ♦ Rigid Ureteroscopy.
 - ♦ Push back (to the kidney) and PCNL.
- 4) Surgical:
 - ♦ Laparoscopic or Open surgery (Ureterolithotomy).

● **Conservative:**

❖ **Indications:**

- ♦ Stones of < 5 mm that did not cause hydronephrosis or infection.

❖ **Conservative treatment:**

- ♦ The patient is treated with analgesics.
- ♦ If the stone did not pass spontaneously within 2 weeks another line of treatment is indicated.

● **Medical Expulsive Therapy (MET):**

❖ **Indications:** For Distal Ureteric stones 5 - 10 mm.

❖ **Aim:** Use of medications to facilitate spontaneous stone passage.

❖ **Medication:** Alpha-receptor Blockers: Tamsulosin.

INDICATIONS FOR ACTIVE TREATMENT OF URETERIC STONES

- 1) Hydronephrosis.
- 2) Urinary Tract Infection.
- 3) Failed Medical Expulsive Therapy.

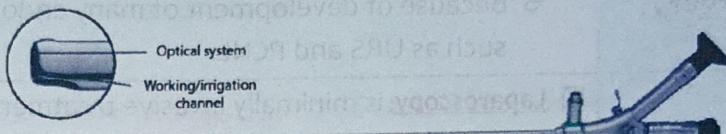
● **Instrumental management:**

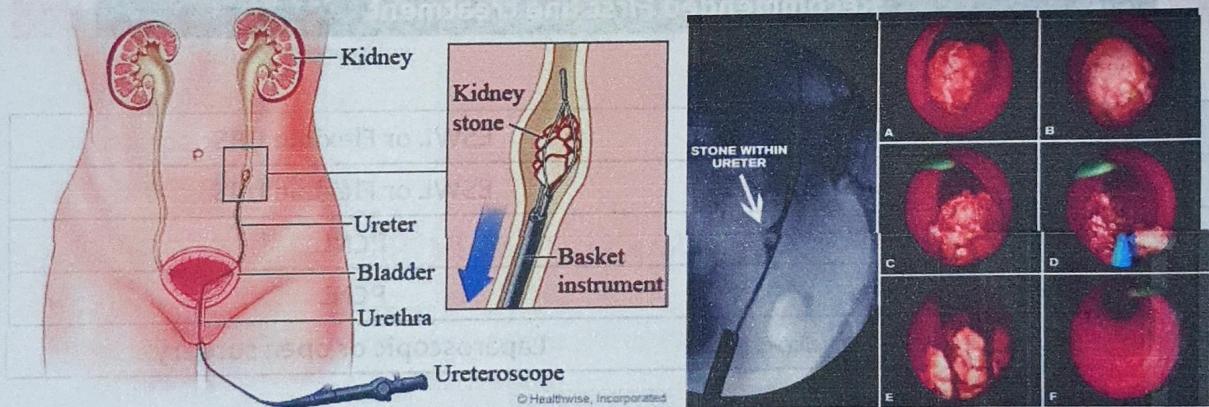
01 ESWL

Indications	<input checked="" type="checkbox"/> Stone size: < 10 mm. <input checked="" type="checkbox"/> Stone Site: in the upper (proximal) ureter.
Contraindications	As renal stones



02 RIGID URETEROSCOPY (URS)

Indications	<ul style="list-style-type: none"> <input checked="" type="checkbox"/> Stone size: > 10 mm. <input checked="" type="checkbox"/> Stone Site: Distal Ureter.  <p>NB: Flexible ureteroscopy can be used for proximal ureteric stones.</p>
Complications	<ol style="list-style-type: none"> 1) Hematuria. 2) Sepsis. 3) Ureteric wall injury (Perforation, Avulsion).



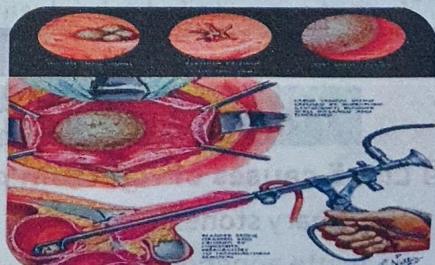
● Surgery:

❖ Procedure: Ureterolithotomy.

TREATMENT OF BLADDER CALCULI

● Instrumental (Cystoscopy):

❖ Procedure: Cystolitholapaxy.



● Open Surgery:

❖ Procedure: Cystolithotomy.



NOTES SURGICAL TREATMENT OF URINARY STONES

Open Surgery	<input checked="" type="checkbox"/> The role of open surgery for treatment of urinary stones is markedly decreased. ↳ Because of development of many endoscopic methods such as URS and PCNL.
Laparoscopy	<input checked="" type="checkbox"/> Laparoscopy: is minimally invasive treatment method. <input checked="" type="checkbox"/> It can replace open surgery for: <ul style="list-style-type: none"> ◆ Treatment of very large stones. ◆ or after failure of other treatment modalities.

Recommended First line treatment

01 RENAL STONES

Stone < 20 mm (not in lower calyx)	ESWL or Flexible URS
Stone < 10 mm in the lower calyx	ESWL or Flexible URS
Stone > 20 mm	PCNL
Staghorn Stones	PCNL
Huge stone or failed other treatments	Laparoscopic or open surgery

02 URETERIC STONE

Proximal Ureteric Stone	< 10 mm > 10 mm	ESWL or Flexible URS
Distal Ureteric Stone	> 5-10 mm > 10 mm	Flexible URS or push back and PCNL Trial MET Rigid URS
Huge stone or failed other treatments		Laparoscopic or open surgery

Some Notes from Clinical Round

☒ List 5 causes of right loin pain in young female.

- 1) Urinary stones.
- 2) Acute appendicitis.
- 3) Acute cholecystitis.
- 4) Torsion of an ovarian cyst.
- 5) Ectopic pregnancy.



**☒ What are emergency situations caused by ureteral stones?**

- 1) Infection (Obstructed infected kidney).
- 2) Bilateral obstruction (Anuria or oliguria).
- 3) Dropped into the urethra > Acute retention.

☒ Explain role of alpha blockers in treatment of ureteral stones.

- 1) Facilitate stone passage.
- 2) Act on alpha adrenoceptors in ureteral smooth muscle.
- 3) Relax the lower ureter.

☒ Mention 5 medical conditions associated with ↑ed risk of stone formation.

- 1) Diabetes.
- 2) Chronic kidney disease.
- 3) Metabolic syndrome.
- 4) Hyperparathyroidism.
- 5) Cardiovascular disease.

☒ How to treat patient with bilateral ureteral stones that cause high serum creatinine?

- ◆ Immediate relieve of the obstruction (Bilateral drainage using JJ stent or nephrostomy tube PCN).
- ◆ Wait for maximum drop of creatinine.
- ◆ Definitive treatment.

☒ List 5 risk factors for stone recurrence after treatment.

- 1) Children.
- 2) Positive family history.
- 3) Recurrent stone.
- 4) Multiple or bilateral stone.
- 5) Predisposing medical condition.

☒ List 5 genetic diseases predisposing stone formation.

- 1) Primary hyperoxaluria.
- 2) Renal tubular acidosis.
- 3) Lesch nyhan syndrome.
- 4) Cystic fibrosis.
- 5) Cystinuria.