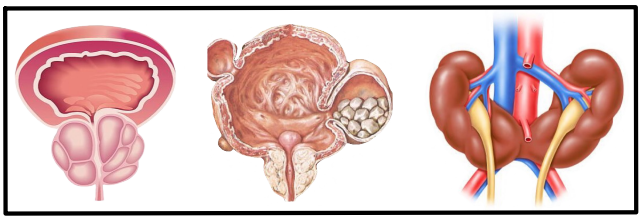
Urinary stones

Incidence:

- Peak incidence is between 20 - 40 years old (No age is immune).
- Males > Females.
- It's common in Egypt due to hot dry climate.
- It presents in 10 - 20 % of population.
- ↑ risk with metabolic syndrome, DM & CVD.



Etiology:

A. Urine stasis: as in BPH, bladder diverticulum, neurogenic bladder, strictures (lower end of ureter & urethra) & horseshoe kidney d.t kinking of both ureters by the isthmus.
N.B: urine stasis can be even caused by a previously formed stone.

B. Excess normal constitutes of urine:

i) ↓ urine volume d.t ↓ water intake & ↑ ↑ sweating → ↑ its concentration.

ii) Excess urinary excretion of calcium:
- Idiopathic (inherited autosomal dominant trait).
- Hyperparathyroidism.
- Prolonged immobilization.

iii) Excess urinary excretion of **uric acid** (end product of purine):
- Gout.
- Chemotherapy d.t ↑ tissue destruction.
- Purine rich food e.g. meat, liver & kidney.

iv) Excess urinary excretion of oxalates:
- Idiopathic (type I & II: autosomal recessive).
- ↑ intake of strawberries, green leafy vegetables & boiled tea.
- Small bowel resection e.g. in Crohn's disease & malabsorption from any cause → ↓ fatty acids & bile salts absorption → ↑ binding of calcium in the process of **saponification** → ↓ calcium-oxalate complex formation & ↑ oxalate absorption.

C. Presence of abnormal constituents in urine:

i) Infection:
- Produces epithelial desquamation upon which calculi deposit (**nucleation**).
- Infection with urea splitting organisms:
  - **Proteus mirabilis** (Commonest)
  - Ureaplasma.
  - Urealyticum.
  - Pseudomonas.
  - Klebsiela.
  - Some staph. aureus.
  - Some strains of E-coli(13 %).
- Splitting of urea into ammonia & carbon dioxide.
- Causing urine alkalinization → favors formation of struvite stones.

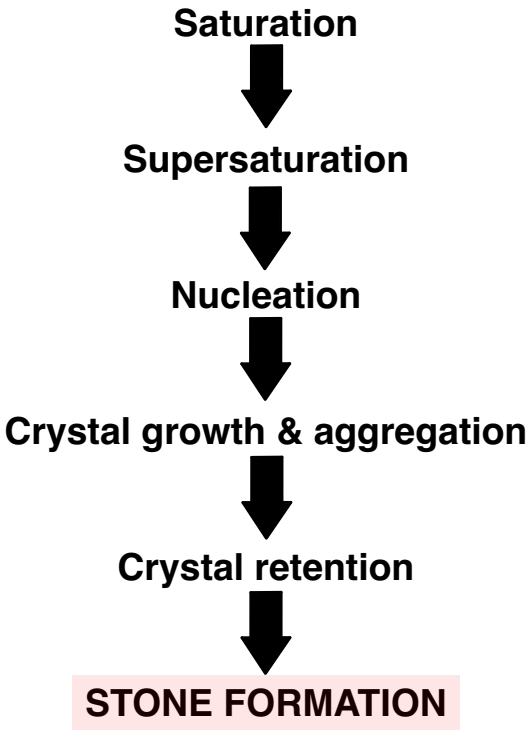
ii) Foreign bodies:
- Act as a nidus for stone formation as non absorbable sutures, ureteric stents or catheters.

iii) Vitamin A deficiency:(rare)
- Causes hyperkeratosis of urothelium → epithelial debris acts as a nidus for stone formation.

iv) Cystinuria (autosomal recessive disease on chromosome 2) → cystine stone formation.

D. Genetic factors: Distal or type 1 RTA, Marfan's syndrome & Wilson's disease.

Pathophysiology:



- **Normal substances that inhibit stone formation (Nucleaion):**
  - Tamm Horsfol protein.
  - Nephrocalcin.
  - Uropontin.

Types of stones:

	Oxalate	Phosphate	Struvite	Uric acid
Structure	COMMONEST UT stone is Ca. oxalate.	Ca. phosphate	Mg & NH4 phosphate.	Uric acid
PH of urine	Acidic (pH < 6)	Alkaline (pH > 7.5)		Acidic
Number	Usually **Single** d.t early pain & hematuria.	Variable		
Size	Small or moderate	Large e.g. stag horn stone		Small
Shape	Oval	Oval or amorphous		Rounded
Surface	Spiky	Smooth or jagged		
Colour	Brown or black (altered blood)	Yellowish white		Golden yellow
Consistency	Very hard	Hard & friable		Hard
Cut section	Radiating spicules	Nucleus & laminae		No nucleus
X-ray	Opaque & spiky	Opaque with laminae		Translucent

1. **Calcium oxalate stones: COMMONEST(up to 70 %)**
   - Monohydrate or Dihydrate.
   - Monohydrate stones are very hard stones (**ESWL resistant**).
   - the activity of stone disease correlates with urinary oxalate excretion rather than the calcium.
   - Oxalate is the strongest chemical promoter of stone production.

2. **Calcium phosphate stones: (6 - 20 %)**
   - Rule out RTA & hyperparathyroidism.

N.B: specific causes of calcium stones:

- Hypercalcuria
- Hyperuricosuria.
- Hyperoxaluria.
- Hypocitraturia:

Types	Absorptive	Renal	Resorptive
	↑ serum calcitrol → ↑ Ca absorption.	Impaired renal proximal tubular reabsorption of Ca.	↑ bone resorption d.t 1ry hyperparathyroidism.

  - Citrate forms a soluble salt with calcium → - - Ca stone formation.
  - Normal citrate level in urine: 300 - 900 mg/24 hours.

3. **Mixed oxalate & phosphate stones: (6 - 20 %)**

4. **Mg ammonium phosphate stones (infection=struvite): (6 - 20 %)**
   - Triphosphate stones.
   - **Most common** cause of staghorn stone.

5. **Urate stones: (6 - 17 %)**
   - Associated with hyperuricemia (+/- gout).
   - It favors calcium oxalate & calcium phosphate stone formation.
   - May form staghorn.
   - Conditions in which urate stones can be formed:
     - Low PH (4.5-5).
     - Low urine volume.
     - Hyperuricosuria (acid urine with low ammonium excretion, autosomal dominant disorder).

6. **Cystine stones: 1-2%**
   - Occurs in cystinuria (recurrent, ESWL resistant).
   - Surface: **Smooth**, Consistency: **Hard**, Radiological: **Faint opaque.**

7. **Miscellaneous, Xanthine, silicate, drug metabolites (1 - 4 %).**

N.B:
- Radiolucent stones don't appear in X-ray but appear in IVP (filling defect), U/S & spiral CT without contrast.
- **C**ystine & **C**alcium oxalate monohydrate are **resistant** to ESWL.

Calcium oxalate stone

Calcium phosphate stones

Triphosphate stones

Staghorn stone

Urate stone

Cystine stones

Clinical picture:

Symptoms:

A. Renal & ureteric stones:

- Asymptomatic (accidentally discovered) in staghorn stone or tiny stone in a calyx.
- Symptoms when a stone gets impacted → obstruction.
- Common sites for stone impaction are:
  i) Pelvi-ureteric junction.
  ii) Level of bifurcation of common iliac artery.
  iii) Level of ischial spine.
  iv) Uretero-vesical junction (intramural part & **ureteric meatus** in UB).
- Pain (**the main symptom**)
  a) Renal pelvic stone
    - Character: fixed dull aching d.t pelvic irritation, distention or stretch of renal capsule.
    - Site: renal angle.
    - Radiation: to the back or hypochondrium anteriorly.
    - ↑ ↑ by movement.

  b) Ureteric stone
    - Character: colicky pain d.t spasm of ureteric smooth muscle.
    - Site: from the renal angle to iliac fossa.
    - Radiation: to groin or scrotum in ♂ or labia majora in ♀ & medial aspect of the thigh (along ilioinguinal & genitofemoral nerve from **T11-L2**).
    - ↑ ↑ by movement.
    - In upper 1/3 → fixed pain in the renal angle.
    - In middle 1/3 → iliac pain simulating appendicitis.
    - In lower 1/3 → suprapubic pain during micturition referred to the tip of penis in ♂ or clitoris in ♀ associated with frequency.
- Nausea &/or vomiting: during pain d.t reflex pylorospasm as T10-12 spinal cord segments give sympathetic supply & receive afferent sensory fibers from the kidney & stomach.
- Hematuria: gross or microscopic d.t mucosal injury during stone migration.

N.B:
- Most common site of renal stone formation is **lower calyx** (most dependent).
- Ureteric stone is formed either d.t **migration** of renal stones, stricture of ureter or diverticulum.
- Ureteric stone is **single** in number, but may be **multiple** if formed above a ureteric stricure.
- Ureteric stone can also cause a ureteric stricture.
- Shape of ureteric stone: rounded then becomes date-shaped.
- A moving stone is often more painful than a static stone.

B. Urinary bladder stones:

- Frequency of micturition: **earliest symptom**
  - Caused by irritation of bladder mucosa & trigone or contraction on the stone.
  - Timing: at first → only diurnal, but if cystitis develops → diurnal & nocturnal.
- From mild discomfort to suprapubic dull aching pain which is:
  - Radiating to the tip of penis or clitoris & perineum (S2-4 segments receive sensations from UB & give pudendal nerve which receive sensations from penis & perineum).
  - More prominent at day time (during micturition).
  - ↓ during sleep or in recumbent position as stone moves away from the trigone.
- Difficult or burning micturition & interrupted urine stream during micturition.
- Acute retention if the stone blocks the internal meatus.
- Terminal hematuria d.t contraction of the bladder on the stone.

N.B: classification of bladder stones:

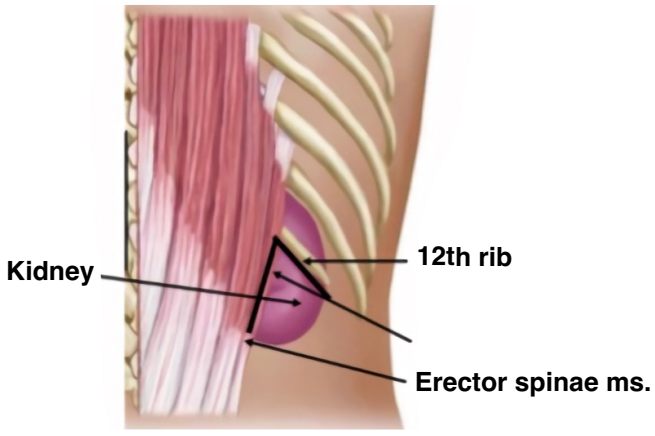
Primary (migratory)	Secondary
- Occurs in sterile urine. - Usually oxalate stone. - Can irritate bladder mucosa causing hematuria.	- Occurs in presence of infection. - Usually phosphate stones. - Occurs in bladder only. - **Commonest** bladder stone.

C. Urethral stones:

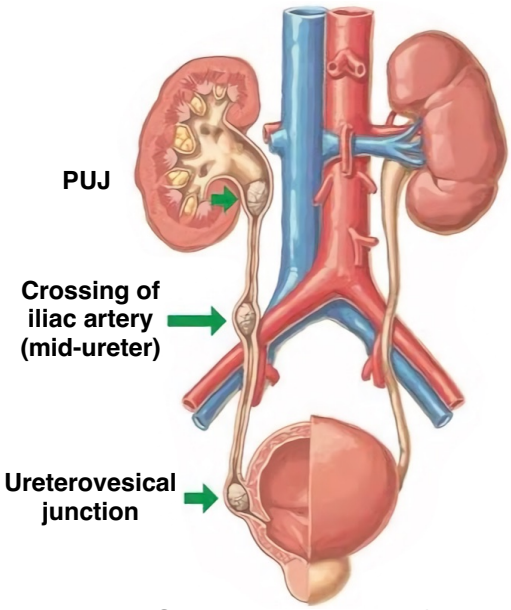
- Sudden arrest of urine followed by acute retention.
- Severe burning urethral pain, difficulty & interruption of micturition stream.

D. Manifestations of infection (pyelonephritis):

- Fever, rigors & loin or flank pain.



Renal angle



Common sites for stone impaction

Signs:

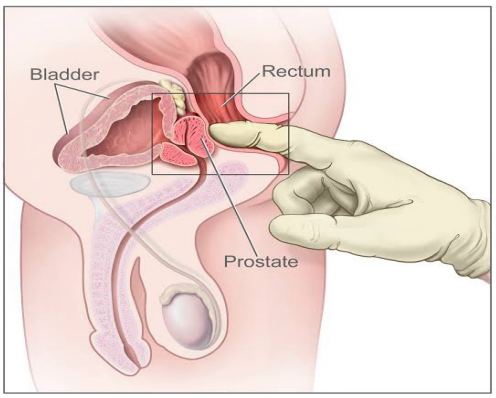
A. General:

- Features of uremia (renal failure) which is preceded by calcular anuria.

B. Local:

- Tender renal swelling.
- Palpable kidney → hydronephrosis or pyonephrosis.
- Tenderness in iliac fossa in ureteric stones.
- Suprapubic tenderness in bladder stones.
- Infraumbilical dullness in retention or fully felt bladder by palpation.
- Stone in the penile (anterior) urethra may be palpated.
- P.R & P.V exam. →
  - Stones are felt in pelvic part of the ureter + tenderness.
  - Huge UB stone may be felt **bimanually**.
  - Stone in the prostatic urethra can be felt.

Kidney palpation



PR examination

PV examination

Complications:

1. Obstruction → stasis, back pressure & proximal dilatation.
   a) Partial or intermittent:
      i) Ureteric stones → hydroureter & hydronephrosis.
      ii) Pelvi-ureteric junction stone → hydronephrosis.
      iii) At neck of calyx → calycial dilatation (hydrocalyx).

   b) Complete:
      i) Calcular anuria
      ii) Acute retention d.t obstruction in the urinary bladder or urethera.
2. Infection as stasis invites infection e.g. pyelonephritis, pyonephrosis, cystitis & urethritis followed by ascending infection to the other side.
3. Hematuria d.t repeated ulceration of the mucosa.
4. Deterioration of renal function d.t obstruction or infection → RF & uremia.
5. Squamous metaplasia of urinary transitional epithelium → sq. cell carcinoma.

Investigations:

A. Laboratory:

a) Urine analysis:

1. Microscopic hematuria (at least 90%) or
2. Crystals of same type that are forming the stone.
3. In struvite stones:
    i) pH is from 8 to 9.
    ii) Pyuria & bacteriuria.
    iii) Culture: urea producing organism.

b) Stone analysis to detect the type of stone.

c) Serum PTH, Ca, P & uric acid to detect the cause.

d) Metabolic workup (24 hours urine collection) for total volume, pH, Ca, citrate, Mg, oxalate, P, Na, uric acid & cystine.

- Indicated in stone former, bil. staghorn stones & in children.

e) KFTs for renal impairment: Serum creatinine is the most accurate.

(N : < 1.4 mg /dL in ♀ & < 1.2 mg/dL in ⇕).

B. Radiological:

1. Computed tomography (CT) (the first-choice) **GOLD STANDARD**

- CT UT without contrast (spiral CT) → visualizes the smallest stones.
- Images can be reconstructed with computer software to produce high quality images of the whole urinary tract.
- It can detect the stone density (Hounsfield unit).
- Visualizes both radio-opaque and radiolucent stones.
- Without contrast → safe in renal impairment.
- Contraindicated in pregnancy.
- Contrast is added to exclude other causes for hematuria e.g. bladder cancer.

2. Plain UT (KUB) (stones are radio-opaque in 90%)

- In descending order of density calcium oxalate is the densest, followed by calcium phosphate, struvite & cystine.
- Uric acid stones are radiolucent.
- A doubtful shadow can be diagnosed by **Lateral view** → Renal stone lies on the vertebral bodies while GB stones lie anterior to the vertebral bodies.

3. Ultrasonography

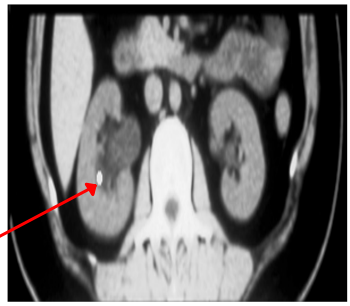
- Advantages:
    i) Simple
    ii) Visualize the kidney & the degree of back pressure changes.
    iii) Diagnose bladder stones & radiolucent calculi.
    iv) SAFE in pregnancy.
- Disadvantage: not reliable to visualize ureteric stones.

4. <u>Intravenous urography (IVU / IVP):</u>

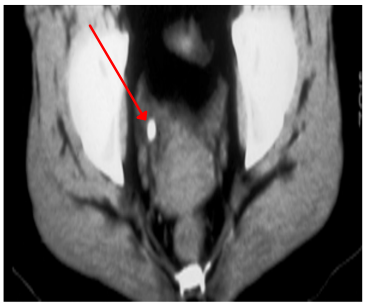
- RARELY used.
- Radiolucent stones appear as **a filling defect**.
- Contraindicated in renal impairment.
- Appearance of renal calyces at various grades of hydronephrosis:
  - Normally → cupped.
  - 1st grade → clubbed.
  - 2nd grade → ballooned.
  - 3rd grade → crescents (sac of urine).

5. <u>MRI:</u> used in case of:
   i) Pregnancy.
   ii) Dye sensitivity of IVU.
   iii) Renal impairment.

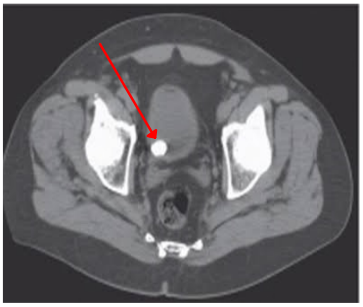
CTUT(without contrast)



Stone kidney



Stone lower 1/3 ureter

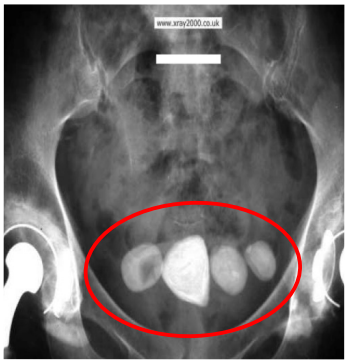


Stone bladder

KUB films

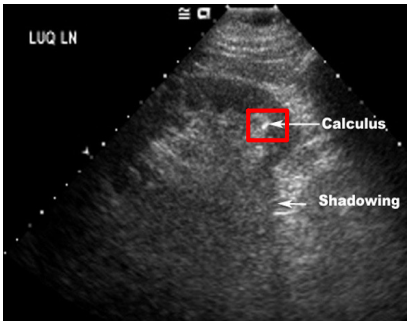
Stone kidney

Stone ureter

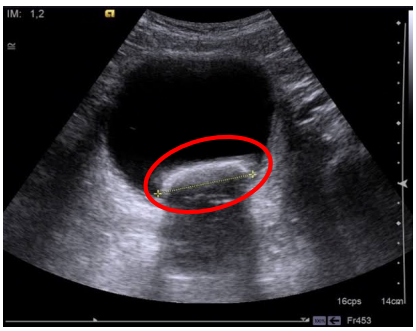


Stones in UB

Ultrasound



Stone kidney



Stone bladder

Factors affecting management of stones:

1) Stones related factors	2) Anatomical factors	3) Patient factors
- Site. - Size. - Number. - Composition.	- Obstruction. - Hydronephrosis. - Horse-shoe kidney. - PUJ obstruction. - Ectopic pelvic kidney. - Bladder stone d.t BPH.	- Obesity. - Infection. - Coagulopathy. - Pregnancy. - Single kidney. - HTN. - Elderly or Pediatrics

4) Facilities availability.

Prevention:

- High water intake esp. in hot weather.
- Avoid excess intake of salt.
- Eat mixed balanced diet.
- Do NOT reduce the intake of calcium.
- Avoid excess intake of animal protein.
- Avoid nuts, spinach, grapefruit, almonds, black tea & dark chocolate as snack (rich in oxalate).
- Many small meals are better than few & large ones.

Treatment:

A. Treatment of renal colic:

- Most cases are treated as outpatients.
- Hospitalization for patients with severe colic with persistent vomiting (it represents 1% of all emergency room visits) →
  1. Parenteral analgesics:
     i) NSAID as indomethacin or diclofenac.
     ii) Narcotic analgesics as opiates (in resistant cases).
  2. Anti-emetics e.g. metochlopramide.
  3. Antispasmodics e.g. aminophylline.
  4. IV fluids are given (according to normal patient's requirements) if vomiting is persistent.
     - Forcing excess fluids during attack → flush out the stone, but if not → ↑ pressure in an obstructed system → ↑ pain.
  5. Antibiotics (if UTI is suspected).

B. Medical treatment for both renal & ureteric stones:

- Purposes:
  - Treatment of acute episode by pain relief & stone expulsion.
  - Prevention of stone recurrence or new stone formation.
- Pharmacological agents: **1) NSAID**

2) Thiazides	3) Orthophosphates	4) Citrates
- Act by ++ Ca resorption in DCT & ++ Na excretion → ↓ urinary Ca by 150 mg/day in normocalcuric pts. & 400 mg/day in hypercalcuric pts. - **DOC** for renal hypercalcuria. - Long term therapy → • volume depletion. • ↓ ECV. • proximal tubular Na & Ca resorption. - Dose: 50 mg twice daily.	- Act by binding dietary Ca in intestine → ↓ Ca absorption → ↓ urinary Ca by 50 % in pts. with absorptive hypercalcuria & 25 % in pts. without this disorder. - Disadvantages: • intolerable • ↑ inhibitor activity of urine & ↑ renal excretion of phosphate & citrate.	- New promising method for prevention of recurrent Ca oxalate stones. - Agents: • sodium potassium citrate. • potassium citrate. - Dose: 30-60 mEq/day in 3 divided doses or single evening dose.

5) α blockers	6) Magnesium	7) Allopurinol
- Act as **medical expulsive** therapy via relaxation of smooth muscle while maintaining tonic propulsive contractions.	- Act by ↑ urinary Mg → produce Mg:Ca in urine → protection against stone formation. - Mg ↓ renal tubular citrate resorption by citrate chelation → ↑ citrate excretion. - S/E: GIT intolerance.	- Act by inhibition of xanthine oxidase & ↓ urate production. - S/E: drug reactions e.g. severe hypersensitivity with thiazides. - Dose: 100 mg 3 times a day.

- **Example:** in urate stones → chemodissolution using potassium citrate effervescent + high fluid intake + low purine diet in certain occasions i.e residual stone after PCNL or lower pole non obstructing renal stone.

C. Surgical treatment of renal stones:

- **Lower pole:**
  a) ≤ 0.4 cm & asymptomatic → conservative (90 % can pass spontaneously).
  b) 0.5 - < 1 cm → ESWL vs. RIRS vs. mini PCNL.
  c) ≥ 1 cm → PCNL.

- **Non lower pole:(in renal pelvis)**
  a) 1-2 cm → ESWL vs. RIRS vs. mini PCNL.
  b) > 2 cm → PCNL or pyelolithotomy (open/laparoscopic/robot assisted)
  c) Huge (Staghorn stones):
     - Staged PCNL.
     - PCNL + ESWL + PCNL (sandwich technique).
     - PCNL + RIRS (new technique).
     - Pyelonephrolithotomy.
     - Conservative ttt in elderly asymptomatic patient & unfit for surgery.

- **In bilateral renal stones:**
  a) Save the less damaged kidney first.
  b) Attack the painful side first.
  c) Attack the side of pyonephrosis first to save life.

D. Surgical treatment of ureteric stones:

- **Upper:**
  a) < 1 cm → ESWL
  b) > 1 cm → RIRS by flexible ureteroscopy & LASER disintegration of the stone → JJ stent insertion → ESWL(< 2 cm) or PCNL(> 2 cm).
  c) Huge/impacted stones→ uretrolithotomy(open/laparoscopic/robot assisted).

- **Mid or lower:**
  a) < 5 mm + **no infection, no hydronephrosis, normal other kidney** → analgesics, α blocker(e.g. tamsulosin) & CCB.
  b) > 5 mm → semi rigid uretroscopy & retreval of stone.
  c) HUGE stones → uretrolithotomy.

- **N.B:**
  - RIRS: retrograde intrarenal surgery.
  - LASER disintegration is the only modality in RIRS.
  - Ureteric stone passage rate:
    i) Upper 1/3: 49 %
    ii) Middle 1/3: 58 %
    iii) Lower 1/3: 68 %
  - 75 % of ureteric stones (< 5 mm) pass spontaneously irrespective of location.
  - Up to 95 % of ureteric stones (≤ 4mm) pass within 40 days.
  - If ureteric stone can't be removed as one part → lithotripsy is done be laser, pneumatic (ballistic) or US techniques.

E. Bladder stones:

- **1-2 cm** → Transurethral cystolithotripsy, if failed → Percutaneous cystolithotripsy.
- **> 2 cm** → Suprapubic cystolithotomy.
- **In pediatric age group** → Percutaneous cystolithotripsy.
- 1ry cause should be treated in 2ry type e.g. TURP + cystolithotomy.

F. Urethral stones:

- Urethral indewling Foley's catheter to push the stone into the bladder, if failed → suprapubic catheter insertion.
- Then deal with the stone as if it's a bladder stone.

G. Multiple level stones: attack the lower stone first as it leads to more damage.

Prognosis:

- Recurrence rate after initial stone: 25-75 % in 10-20 years of follow up.

Various modalities for stone disintegration & removal

1. Extracorporeal shock wave lithotripsy (ESWL):

- Most common way to treat stones.
- **Principle** (done under IV sedation)
  - High-energy shock waves that are focused from outside the body on the stone (after its visualization using **X-ray** or ultrasonic imaging).
  - The stone is fragmented → pass out through the normal pathway.
  - High fluid intake is maintained to facilitate passage of gravels.
- **Advantages:** non-invasive & suitable for all patients.
- **Disadvantages:**
  - **i)** 20 % of stones won't be broken into small pieces.
  - **ii)** 20 % of stones will fail to pass out of the patient after the ttt.
  - **iii)** Urate stones are radiolucent & may cause some difficulty.
  - **iv)** Painful passage of stone pieces.
- **Contraindications:**
  - **a) Urological:**
    - i) Presence of distal obstruction (fragments will not pass).
    - ii) Stone (>2cm) except after debulking of stone by PCNL.
    - iii) Solitary kidney except after stenting of ureter to avoid acute ureteric obstruction & anuria.
    - iv) Renal insufficiency (kidney has no power to push fragments).
    - v) Acute episode of renal infection.
  - **b) Non-urological:**
    - i) Pregnancy.
    - ii) Arterial aneurysm near stone (renal or **AAA**).
    - iii) Uncorrected coagulopathy or bleeding diathesis.
- **Complications:**
  - **a) Related to stone passage:**
    - i) Transient attacks of hematuria.
    - ii) Renal colic.
    - iii) Steinstrasse.
  - **b) Related to shock wave:**
    - i) Skin bruising.
    - ii) Subcapsular hematoma.
    - iii) Pancreatitis.
    - iv) Urosepsis.
    - v) Hearing loss for the physician.

- **Efficacy of ESWL:**
  - **a) Stone kidney:** <u>< 2 cm</u> → up to 90 %
  - **b)** Upper ureteric stones:
    - **i)** Non impacted → up to 90 %
    - **ii)** Impacted → up to 60 %
  - **c)** Mid ureteric stones: up to 80 %

2. Percutaneous nephrolithotomy (PCNL):

- **Indications:**
  - i) Large stone burden (> 2 cm).
  - ii) Large lower pole lower stone.
  - iii) Ca. oxalate monohydrate stone or Cystine stone.
  - iv) Distal obstruction.
  - v) Abnormalities of renal & upper tract anatomy.
  - vi) Abnormalities of patient's anatomy e.g obesity & deformity.
  - vii) ESWL failure.
- **Contraindications:**
  - i) Pregnancy (X-ray exposure).
  - ii) Bleeding diathesis.
  - iii) Renal anomalies, but in horseshoe kidney is done through upper calyx.
- **Steps:**

1. Contrast material is injected up a ureteric catheter to visualize the pelvicalyceal system under **X-ray** or US.
2. A needle is passed to the pelvis through which a guide-wire is inserted.
3. The tract is dilated over the guide wire to a size sufficient to accommodate the nephroscope.
4. Stone manipulation:
   - Small stones < 1cm → directly extracted through the sheath.
   - Large stones are fragmented first through nephroscope by either ultrasonic, pneumatic or laser lithotripsy.
5. Removal of residual fragments by using irrigating fluid.
6. Finally, a nephrostomy tube is left in situ for 48 hours to allow drainage of residual tiny fragments, urine & blood.

- **Advantages:**
  - i) Very small endoscopic incision (1 cm).
  - ii) Minimal operative & post-operative side effects.
  - iii) Short hospital stays (about 3 days).

- **Complications:**
  - i) Kidney bleeding.
  - ii) Extravasation of irrigating fluid into peritoneum or retroperitoneum.
  - iii) Perforation.
  - iv) Injury to adjacent organs e.g. pleura & colon.
  - v) Infection.

3. Uretroscopy (URS):

- Is the **gold standard** for treatment of middle and lower ureteric stones.
- Flexible ureteroscopes are available for diagnostic & therapeutic uses because of the deflection capabilities.
- Rigid ureteroscopes are **easier** for stone manipulation.
- The stones are removed using the stone basket or graspers (size ≤ 0.6 cm)
- Endoscopic lithotripsy devices are used for stone fragmentation (> 0.6 cm), (ultrasonic, laser or pneumatic).
- **Complications:**
    i) Failure.
    ii) Mucosal abrasions.
    iii) False passages.
    iv) Ureteral perforation.
    v) Ureteral avulsion.
    vi) Ureteral stricture.

4. Cystoscopic lithotripsy:

- **Indication:** stones < 2 cm.
- **Steps:**
    i) The stone is crushed cystoscopically by ultrasonic waves or by pneumatic shock waves.
    ii) Fragments are then lavaged cystoscopically to outside the bladder by **Ellik** evacuator.

5. Open Pyelolithotomy:

- **Definition:** opening the renal pelvis in **posterior aspect** to avoid the hilum of the kidney (renal artery & renal vein), then removal of the stone.
- It's done through **a lumbar supracostal muscle cutting incision**.
- **Advantages:**
    i) Not cause any damage to renal parenchyma.
    ii) Minimal bleeding.
    iii) Rapid healing.

6. Open Nephrolithotomy:

- **Definition:** incision through renal parenchyma to remove a stone.
- It's done through **a lumbar supracostal muscle cutting incision**.
- The incision in the kidney may be:
    a) In the Brodel's blodeless line (1/2 cm parallel to convex border of the kidney).
    b) Radial incision directly on the stone.
- **Indication:**
    i) Difficulty in exposing the renal pelvis.
    ii) When stone is large & palpable through thin renal parenchyma.

7. Open Pyelonephrolithotomy (combines the above two procedures):

- **Indication:** staghorn stone.

8. Partial nephrectomy:

- **Indication:** impacted stone in a hugely dilated lower calyx with narrowing of its neck causing cavitation & destruction of the lower part of the kidney.

9. Nephrectomy:

- **Indication:** hopeless kidney (non functioning) provided that the contralateral kidney possesses a good function.

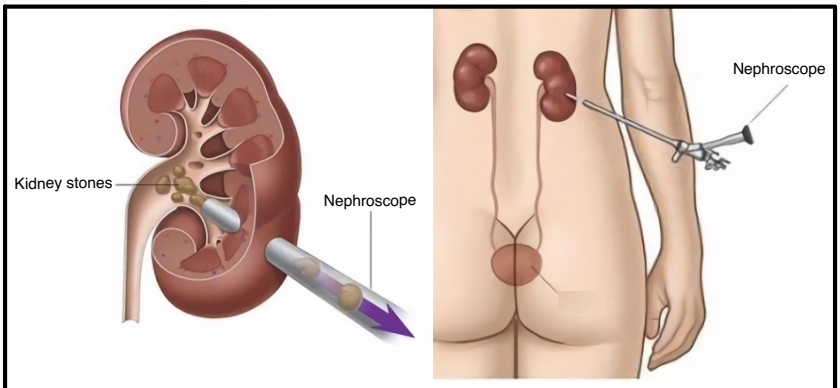
10. Open Uretrolithotomy:

- **Steps:**
    - **a) Incision:**
        - i) Stones in upper 1/3 →
            - **Morris'** lumbar incision:
                - ◉ This is a muscle cutting incision that starts at renal angle & carried downward & forwards parallel to & about 1 inch below last rib to avoid pleural injury.
                - ◉ It ends 1/2 inch above & medial to ASIS. **OR**
            - **Foley's** lumbar incision: muscle splitting incision.
        - ii) Middle 1/3 → **Abernathy's** incision (a muscle cutting incision that starts above the anterior superior iliac spine & passes downwards & medially parallel to the lateral 1/2 of inguinal ligament).
        - iii) Lower 1/3 →
            - **Lower midline** OR
            - Pfannenstiel's (transverse) incision in ♀.
    - **b) Plain X-ray just before the operation is important.**
    - **c) At any level, the ureter is exposed by an extraperitoneal route** (peritoneum is not opened but is peeled medially)**.**
    - **d) It is preferable to open ureter in a healthy area above the stone.**
    - **e) The stone is removed by a ureterolithotomy forceps.**
    - **f) A small ureteric catheter (6F) is passed downwards the ureter to check its patency & to exclude any stricture.**
    - **g) The ureter incision is closed by fine 4-0 Vicryl suture.**
    - **h) A drain is inserted and the wound is closed in layers.**

11. Open Cystolithotomy:

- **Indications:**
    i) Stone > 2 cm.
    ii) Multiple stones.
    iii) Stone in a diverticulum (has thin wall, so easy to perforate).
    iv) Presence of another pathology needing surgery.
    v) Failure of crushing the stone.
- **Steps:**
    a) Low midline incision or a Pfannenstiel's transverse incision in ♀.
    b) The peritoneum is peeled upwards.
    c) The bladder is identified by:
        i) Its trabeculated muscular wall.
        ii) The presence of a plexus of veins over its surface.
    d) The bladder wall is held between 2 bladder forceps & opened.
    e) The stone is extracted and the bladder is inspected for any associated pathology.
    f) The bladder is closed in 2 layers with 2-0 Vicryl after insertion of a suprapubic tube or a urethral catheter.
    g) The prevesical space is drained and the wound is closed.

ESWL



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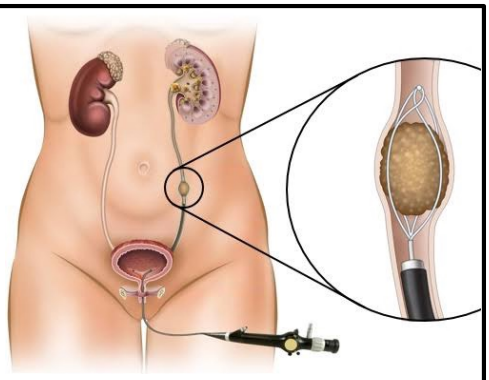

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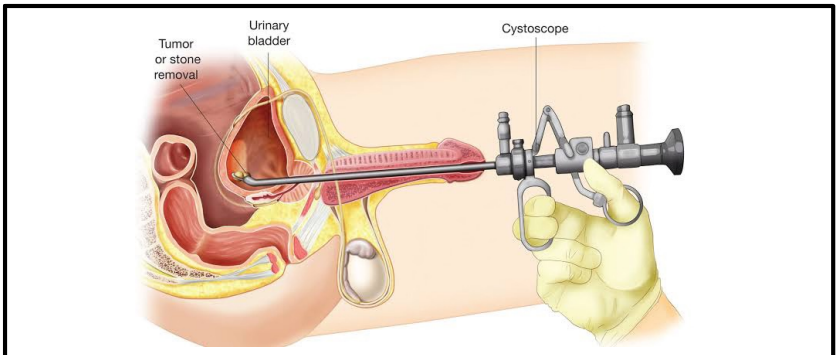
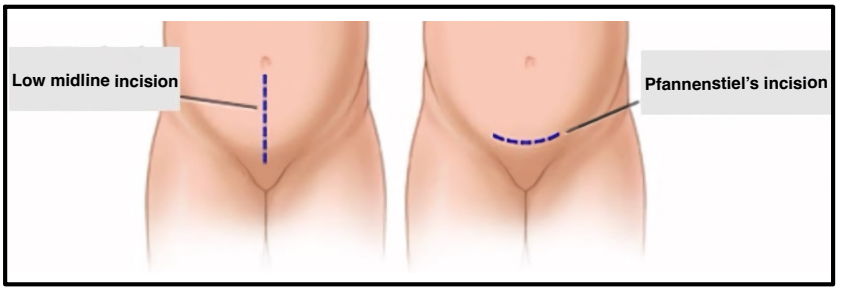


Cystoscopy



Calcular anuria

Definition: arrest of urine flow.

Etiology:

A. Stone obstructing the ureter of an only functioning kidney (The other is nonfunctioning, surgically removed or congenitally absent).
B. Bilateral renal or ureteric calculi.

Pathophysiology:

- Complete obstruction → accumulation of urine in Bowman's capsules of renal nephrons → ↑ pressure in Bowman's capsules till it equals the pressure in the glomeruli → **anuria.**

Clinical picture:

A. Stage of onset: An attack of ureteric colic is followed by anuria (colic may be absent).

B. Stage of tolerance:

i) Colic disappears & there are no major symptoms or signs.
ii) Still there is no urine output
iii) Urea & creatinine start to rise.

C. Stage of uraemia (renal failure): Later, clinical picture of uremia will follow within a few days.

Investigations:

A. Laboratory:

- ↑ Blood urea.
- ↑ Creatinine.
- Hyperkalemia.
- Metabolic acidosis.

B. Radiological: imagining US → empty bladder & hydronephrosis.

Treatment: it's a urological emergency.

- Drainage of obstructed kidney(s) by:
  a) Double J endoscopically OR
  b) US guided PCN under GA.

- Nephrology consultation → possibility of dialysis because of sever metabolic acidosis or severe hyperkalemia.
- Deal with the stone when condition of patient becomes stable.