Calculi

What are Calculi?

- A **calculus** (plural **calculi**), often called a **stone**, is a concretion of material, usually mineral salts, that forms in an organ or duct of the body.
- Formation of calculi is known as **lithiasis**.
- Stones can cause a number of medical conditions.

Types of Calculi

- Calculi in the urinary system are called urinary calculi and include kidney stones (also called renal calculi or nephroliths) and bladder stones (also called vesical calculi or cystoliths). They can have any of several compositions, including mixed. Principal compositions include oxalate and urate.
- Calculi of the gallbladder and bile ducts are called gallstones and are primarily developed from bile salts and cholesterol derivatives.
- Calculi in the nasal passages (rhinoliths) are rare.
- Calculi in the gastrointestinal tract (enteroliths) can be enormous. Individual enteroliths weighing many pounds have been reported in horses.
- Calculi in the stomach are called gastric calculi (gastroliths).
- Calculi in the salivary glands are called salivary calculi (sialoliths).
- Calculi in the tonsils are called tonsillar calculi (tonsilloliths).
- Calculi in the veins are called venous calculi (phleboliths).
- Calculi in the skin, such as in sweat glands, are not common but occasionally occur.

Calculi are usually asymptomatic, and large calculi may have required many years to grow to their large size.

Causes

- From an underlying abnormal excess of the mineral, e.g., with elevated levels of calcium(hypercalcaemia) that may cause kidney stones, dietary factors for gallstones.
- Local conditions at the site in question that promote their formation, e.g., local bacteria action (in kidney stones) or slower fluid flow rates, a possible explanation of the majority of salivary duct calculus occurring in the submandibular salivary gland.
- Enteroliths are a type of calculus found in the intestines of animals (mostly ruminants) and humans, and may be composed of inorganic or organic constituents.
- Bezoars are lumps of indigestible material in the stomach and/or intestines; most commonly, they consist of hair (in which case they are also known as hairballs). A bezoar may form the nidus of an enterolith.
- In kidney stones, calcium oxalate is the most common mineral type (see Nephrolithiasis). Uric acid is the second most common mineral type, but an *in vitro* study showed uric acid stones and crystals can promote the formation of calcium oxalate stones

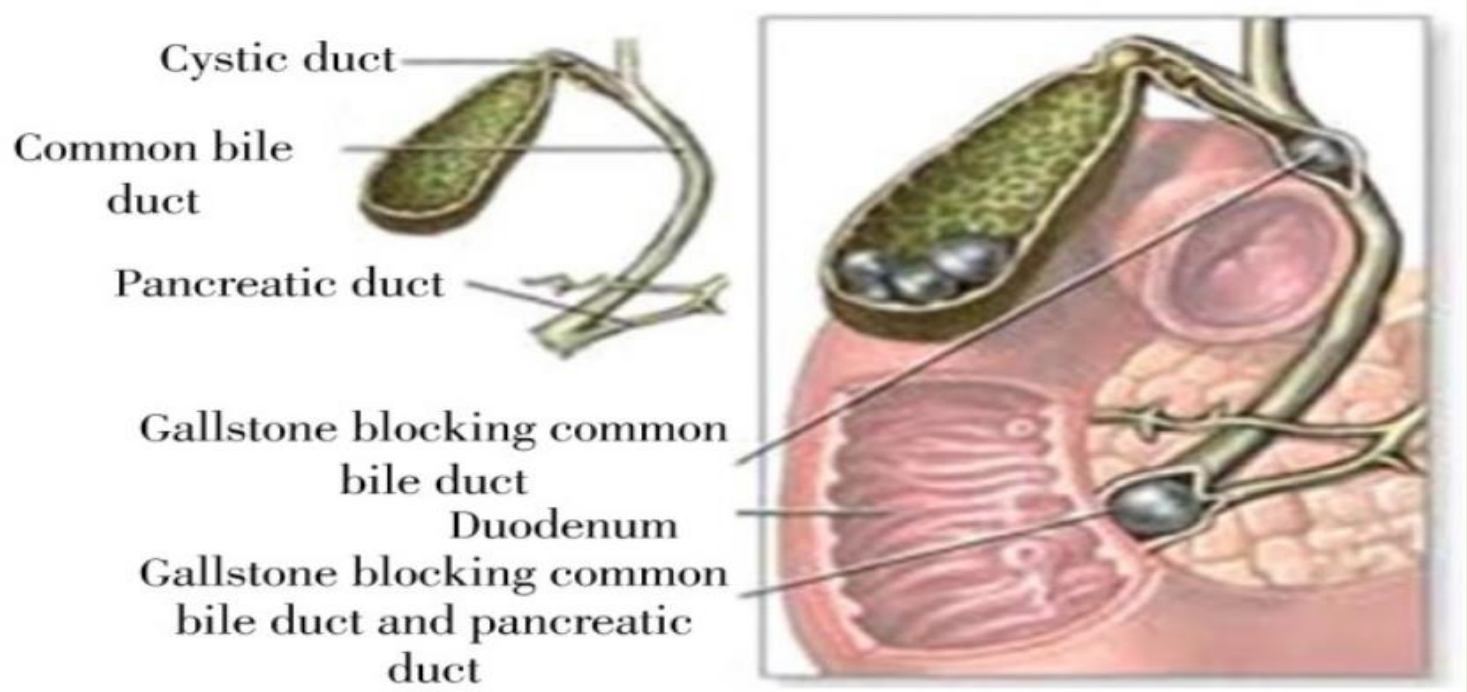
Analysis of Calculi

- We are discussing here about Gall stones and Urinary calculi here.

Gallstones:

Gallstones are collections of cholesterol, bile pigment, which can form in the gallbladder or surrounded by the bile ducts of the liver. In the United States, the most universal category of gallstones is made of cholesterol. Cholesterol stones are mainly causes due to difference in the production of cholesterol or the secretion of bile. Pigmented stones are mainly composed of bilirubin, which is an element formed due to the normal breakdown of red blood cells. Bilirubin gallstones are more common in Asia and Africa but they are seen in diseases that break red blood cells such a sickle cell anaemia.

Gallstones


Cystic duct
Common bile duct
Pancreatic duct
Gallstone blocking common bile duct
Duodenum
Gallstone blocking common bile duct and pancreatic duct

Gallstones

- Cholelithiasis is the presence of one or more calculi (gallstones) in the gallbladder. In developed countries, about 10% of adults and 20% of people > 65 years have gallstones.
- Gallstones tend to be asymptomatic. The most common symptom is biliary colic; gallstones do not cause dyspepsia or fatty food intolerance.
- More serious complications include cholecystitis (inflammation of the gallbladder); biliary tract obstruction (by stones in the bile ducts [choledocholithiasis]), sometimes with infection (cholangitis); and gallstone pancreatitis. Diagnosis is usually by ultrasonography. If cholelithiasis causes symptoms or complications, cholecystectomy (removal of gallbladder) is necessary.

Gallstones- Risk Factors

Risk factors for gallstones include:

- Pregnancy, progesterone decreases the contractility of the gallbladder leading to stasis
- Obesity
- Genes
- Certain medications (estrogens, fibrates, somatostatin analogs)
- Stasis of the gallbladder
- Female gender
- Metabolic syndrome
- Rapid weight loss
- Prolonged fasting
- Bariatric surgery
- Crohn disease, ileal resection

Gallstones- Pathophysiology

- **Biliary sludge** is often a precursor of gallstones. It consists of calcium bilirubinate (a polymer of bilirubin), cholesterol microcrystals, and mucin.
- Sludge develops during gallbladder stasis, as occurs during pregnancy or use of total parenteral nutrition.
- Most sludge is asymptomatic and disappears when the primary condition resolves. Alternatively, sludge can evolve into gallstones or migrate into the biliary tract, obstructing the ducts and leading to biliary colic, cholangitis, or pancreatitis.

Gallstones- Types

There are several types of gallstones.

1-Cholesterol Stones

2-Black Pigmented Stones

3-Brown Pigmented Stones

- **Cholesterol stones** account for > 85% of gallstones in the Western world. For cholesterol gallstones to form, the following is required:
  - Bile must be supersaturated with cholesterol. Normally, water-insoluble cholesterol is made water soluble by combining with bile salts and lecithin to form mixed micelles. Super saturation of bile with cholesterol most commonly results from excessive cholesterol secretion (as occurs in obesity or diabetes) but may result from a decrease in bile salt secretion (eg, in cystic fibrosis because of bile salt malabsorption) or in lecithin secretion (eg, in a rare genetic disorder that causes a form of progressive intrahepatic familial cholestasis).

Gallstones-Types

- The excess cholesterol must precipitate from solution as solid microcrystals. Such precipitation in the gallbladder is accelerated by mucin, a glycoprotein, or other proteins in bile.
- The microcrystals must aggregate and grow. This process is facilitated by the binding effect of mucin forming a scaffold and by retention of microcrystals in the gallbladder with impaired contractility due to excess cholesterol in bile.

- **Black pigment stones** are small, hard gallstones composed of calcium (Ca) bilirubinate and inorganic Ca salts (eg, Ca carbonate, Ca phosphate). Factors that accelerate stone development include alcohol-related liver disease, chronic hemolysis, and older age.
- **Brown pigment stones** are soft and greasy, consisting of bilirubinate and fatty acids (Ca palmitate or stearate). They form during infection, inflammation, and parasitic infestation (eg, liver flukes in Asia).

Gallstones-Symptoms and Signs

- About 80% of people with gallstones are asymptomatic. The remainder have symptoms ranging from a characteristic type of pain (biliary colic) to cholecystitis to life-threatening cholangitis.
- Stones occasionally traverse the cystic duct without causing symptoms. However, most gallstone migration leads to cystic duct obstruction, which, even if transient, causes biliary colic. Biliary colic characteristically begins in the right upper quadrant but may occur elsewhere in the abdomen. It is often poorly localized, particularly in diabetics and older patients. The pain may radiate into the back or down the arm. Biliary colic is the most common symptom.

Gallstones-Symptoms and Signs

- Episodes begin suddenly, become intense within 15 minutes to 1 hour, remain at a steady intensity (not colicky) for up to 12 hours (usually < 6 hours), and then gradually disappear over 30 to 90 minutes, leaving a dull ache. The pain is usually severe enough to send patients to the emergency department for relief. Nausea and some vomiting are common, but fever and chills do not occur unless cholecystitis has developed. Mild right upper quadrant or epigastric tenderness may be present; peritoneal findings are absent. Between episodes, patients feel well.
- Although biliary colic can follow a heavy meal, fatty food is not a specific precipitating factor. Nonspecific gastrointestinal symptoms, such as gas, bloating, and nausea, have been inaccurately ascribed to gallbladder disease. These symptoms are common, having about equal prevalence in cholelithiasis, peptic ulcer disease, and functional gastrointestinal disorders.

Gallstones-Symptoms & Signs

- Little correlation exists between the severity and frequency of biliary colic and pathologic changes in the gallbladder. Biliary colic can occur in the absence of cholecystitis. If colic lasts > 12 hours, particularly if it is accompanied by vomiting or fever, acute cholecystitis or pancreatitis is likely.

Gallstones- Diagnosis

By Ultrasonography

- Gallstones are suspected in patients with biliary colic. Abdominal ultrasonography is the imaging test of choice for detecting gallbladder stones; sensitivity and specificity are 95%. Ultrasonography also accurately detects sludge.
- CT, MRI, and oral cholecystography (rarely available now, although quite accurate) are alternatives.
- Endoscopic ultrasonography accurately detects small gallstones (< 3 mm) and may be needed if other tests are equivocal.
- Laboratory tests usually are not helpful; typically, results are normal unless complications develop.
- Asymptomatic gallstones and biliary sludge are often detected incidentally when imaging, usually ultrasonography, is done for other reasons. About 10 to 15% of gallstones are calcified and visible on plain x-rays.

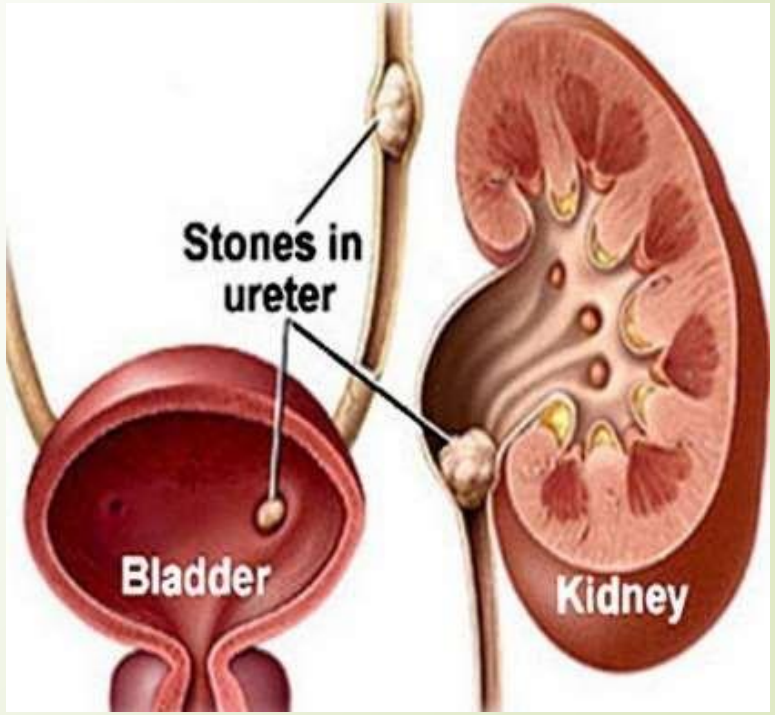
Gallstones-Treatment

- For symptomatic stones: Laparoscopic cholecystectomy or sometimes stone dissolution using ursodeoxycholic acid
- For asymptomatic stones: Expectant management
- Most asymptomatic patients decide that the discomfort, expense, and risk of elective surgery are not worth removing an organ that may never cause clinical illness. However, if symptoms occur, gallbladder removal (cholecystectomy) is indicated because pain is likely to recur and serious complications can develop.

Urinary Stones

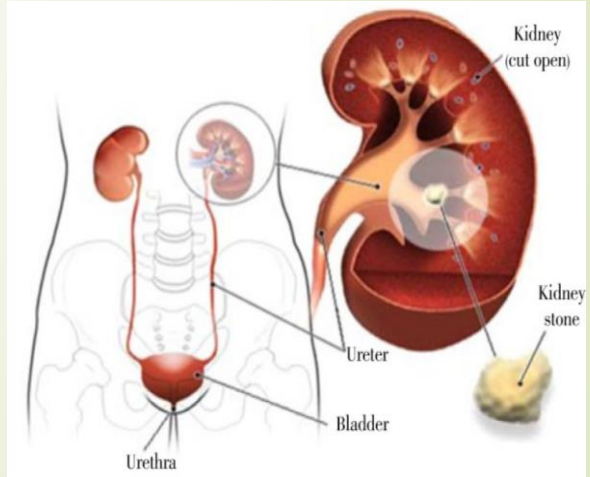
Classification-

- **Kidney Stones or Renal Calculi (Nephrolithiasis)**
- **Stone in ureter (Ureterolithiasis)**
- **Stone in Urinary bladder**



Renal Calculi

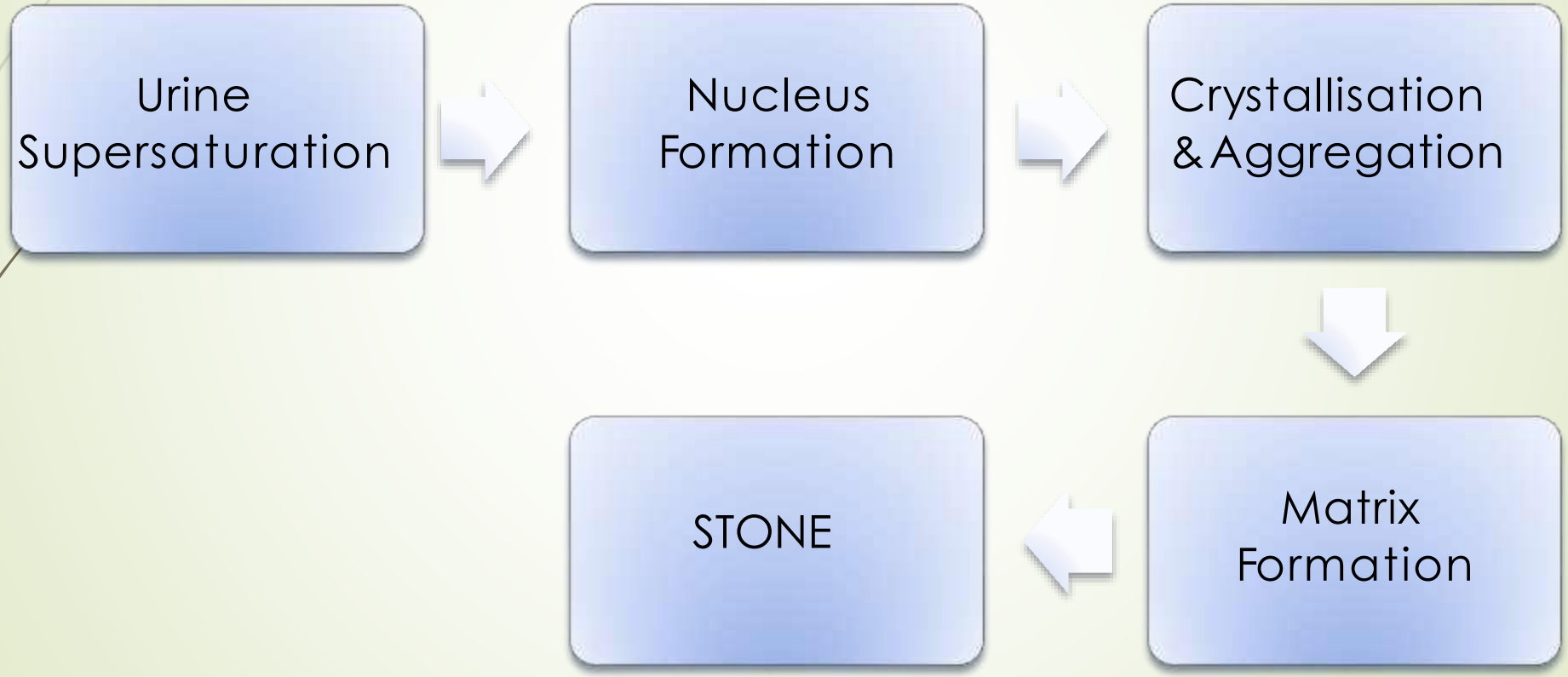
- Kidney stones are called Renal Calculi.
- Nephrolithiasis is process of formation of kidney stones.
- Kidney stones are crystal aggregations formed in the kidneys. Kidney stones normally leave the body by the route of urine stream, and many stones are produced and conceded without causing symptoms. If stones grow to plenty size before passage, they can cause barrier of the ureter.



Renal Calculi- Risk factors

- Infection: By Proteus, E.coli, Recurrent UTI,
- Diet: Vit. A deficiency, Calcium rich diet etc.
- Hot Climate.
- Metabolic causes: Gout, hyperoxaluria etc
- Prolonged Immobilisation.
- Others: decreased urinary citrate, stasis, dehydration, sedentary lifestyle etc.

Pathophysiology/ Stone formation



Types of Stone

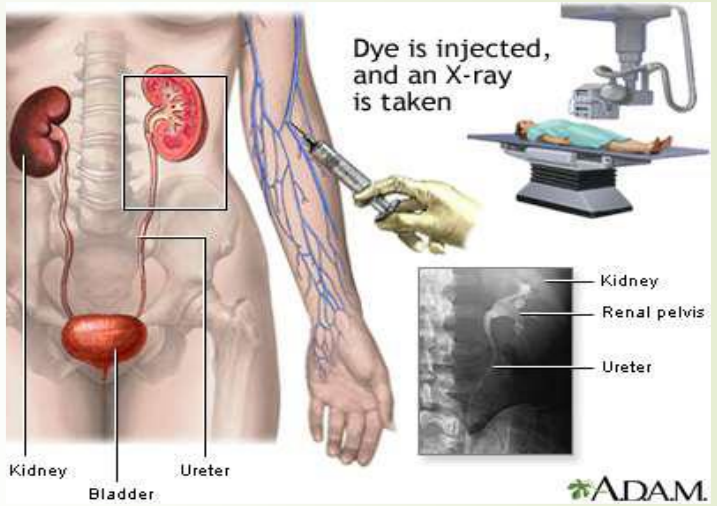
Calcium Oxalate stones (75%)	• Hard, single, brown in colour • Mulberry stones
Phosphate stones (10-15%)	• Smooth, round ,white in colour • Staghorn calculus
Uric acid stones(5%)	• Multiple, yellowish,radioluscent • Seen in gout etc
Cystine stones (2%)	• Seen in cystinuria, • Hard, radio-opaque due to sulphur

Clinical Features

- Renal pain
- Guarding and Rigidity
- Ureteric Colic
- Hematuria
- Pyuria,
- Fever
- Recurrent UTI

Investigations

- Blood
- Urine- R/M & Culture + sensitivity.
- Plain X-ray, KUB Region
- Ultrasonography
- IVP(Intravenous pyelogram)
- RGP(Retrograde Pyelography)
- CT scan (contrast/ non contrast)



Treatment

Non - Operative

- Conservative: Flush Therapy; I.V fluids etc.
- **ESWL** (Extracorporeal Shock Wave Lithotripsy)

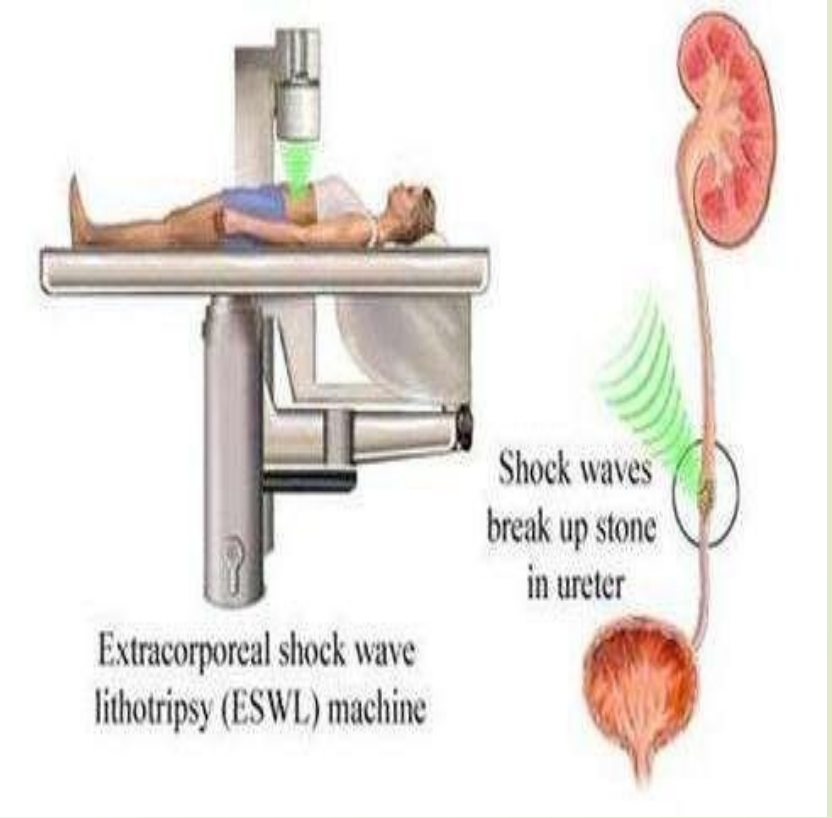
Operative

- Endoscopic procedures: **PCNL** (percutaneous nephrolithotomy)
- Surgical procedures

ESWL(Extracorporeal Shock Wave Lithotripsy)

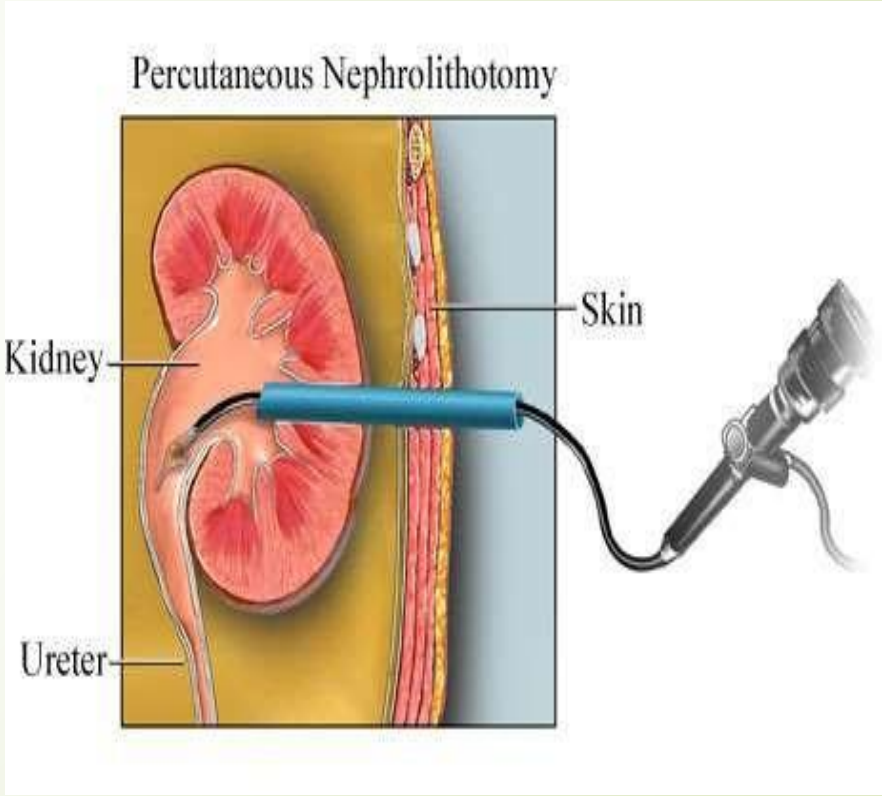
- **Electromagnetic Shock** waves are produced.
- **Dornier Lithotripter** is used for fragmenting stones.

- **Advantages:**
  No anaesthesia No incision
  No Pain
- **Complications:**
  Renal haematom
  Severe haematuria
  Steinstrasse (stone street)
- **Contraindications:**
  Pregnancy, Bleeding disorders
  Abdominal aneurysm



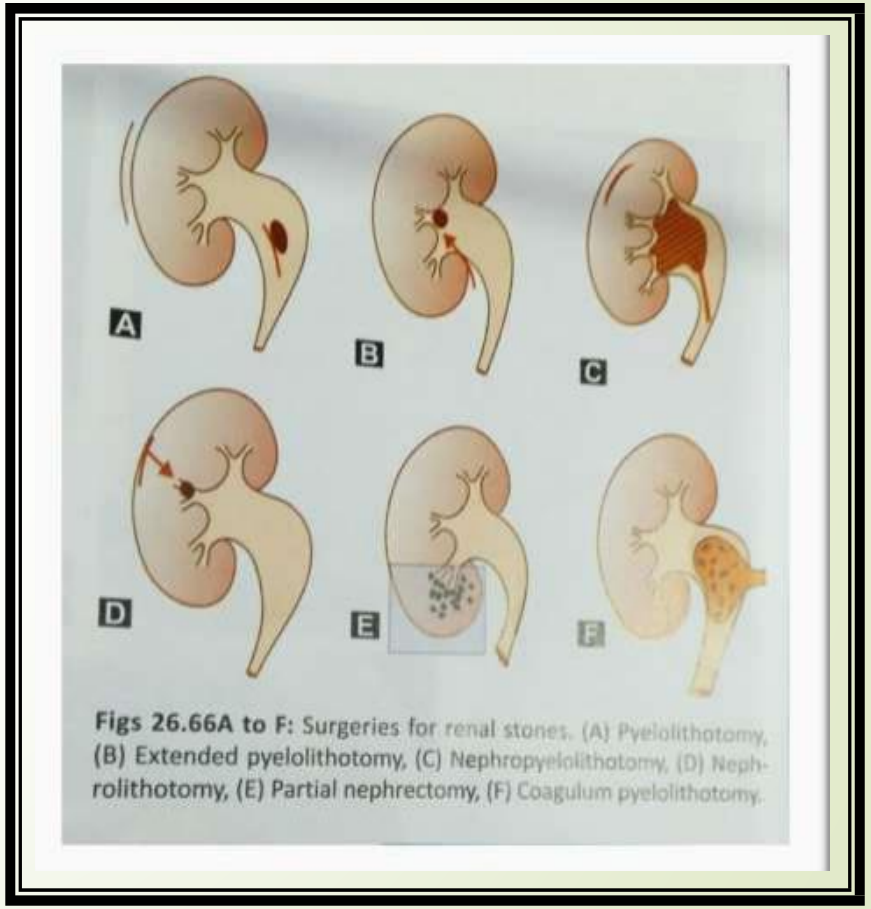
Percutaneous Nephrolithotomy

- **Indications:**
  - Stones not responding to ESWL
  - Stones more than 2.5 cm in size
  - Multiple Stones
- **Complications:**
  - Haemorrhage
  - Injury to colon or pluera
  - Perforation of collecting duct



Surgery

- **Pyelolithotomy:** for stones in extrarenal pelvis.
- **Extended Pyelolithotomy.**
- **Nephrolithotomy.**
- **Pyelonephrolithotomy.**
- **Partial Nephrectomy.**
- **Nephrectomy.**
- **Coagulum pyelolithotomy**

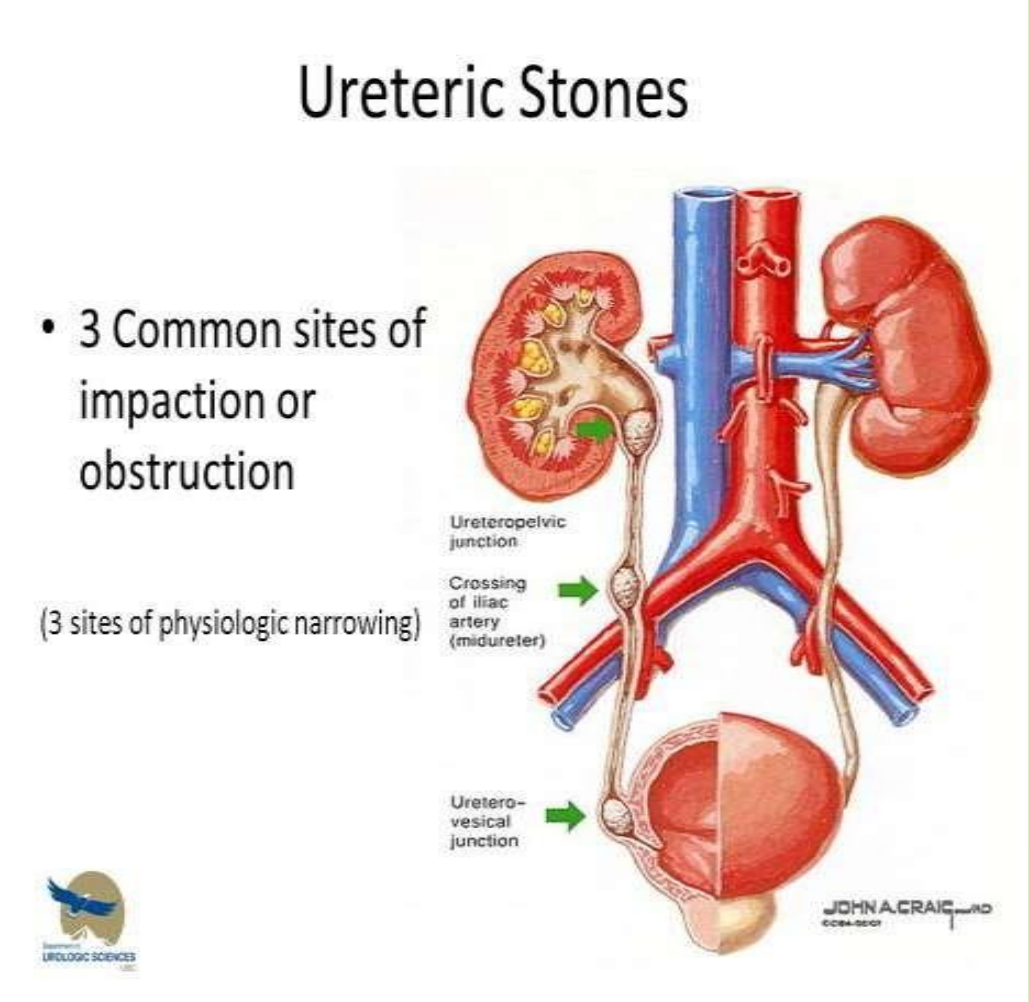


Figs 26.66A to F: Surgeries for renal stones. (A) Pyelolithotomy, (B) Extended pyelolithotomy, (C) Nephropyelolithotomy, (D) Nephrolithotomy, (E) Partial nephrectomy, (F) Coagulum pyelolithotomy.

Ureteric Calculi

- Always of renal origin.
- Stones gets impacted at sites of ureteric narrowing, namely

1. Pelviureteric Junction (PUJ)
2. Crossing of the iliac artery
3. Crossing of Vas deferens or broad ligament
4. Site of entry into the bladder
5. Ureteric Orifice



Ureteric Calculi – Clinical Feature

- Pain –colicky type ,radiating

  - mimics *appendicitis, cholecystitis, ovarian or tubal* pathology.
- Nausea , Vomiting etc.
- Hematuria, dysuria, pyuria etc.
- Tenderness in Iliac fossa & Renal Angle

Ureteric Calculi- Complications

- Obstruction
- Hydronephrosis
- Infection
- Impaction
- Ureteral Stricture

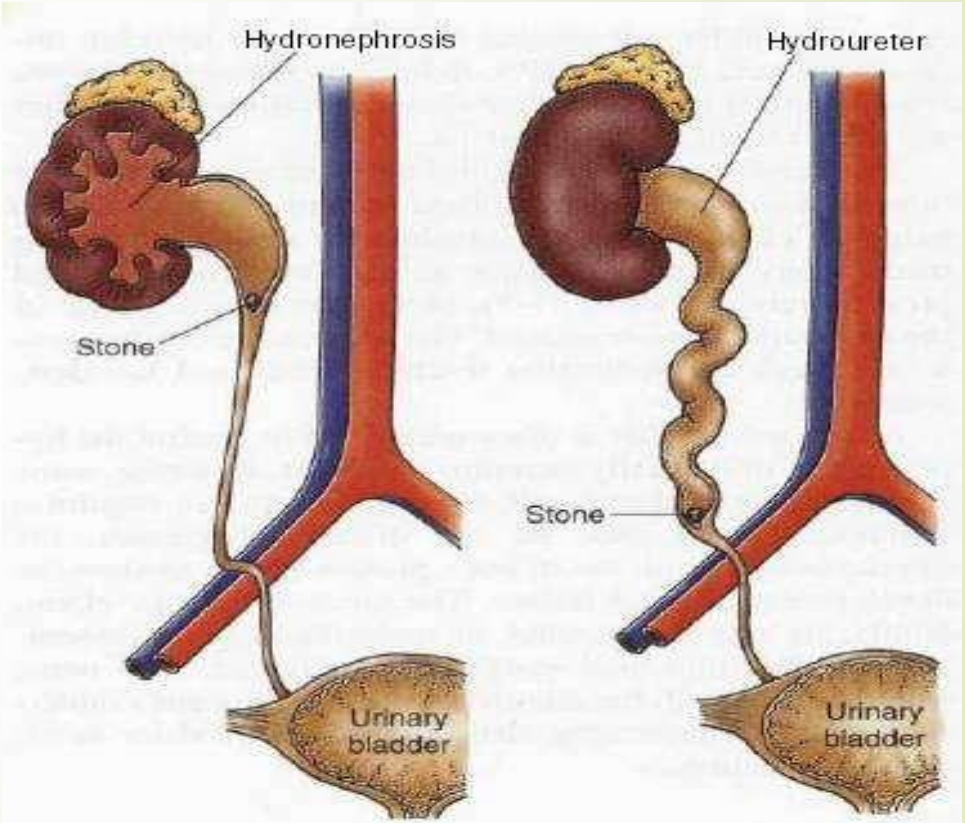


Figure 71-2 • Hydronephrosis is caused by obstruction in the upper part of the ureter; hydroureter is caused by obstruction in the lower part of the ureter.

Ureteric Calculi

Investigations

- Urine and bloodtests
- Plain X-ray, KUB, IVU, CT-scan

Treatment

- Conservative: Flush Therapy
  I.V Fluids, antibiotics, antispadmotic etc
- Surgical Interventions

Ureteric Calculi-Surgical Interventions

INDICATION:
size of stone more than 6-8 mm. IVU showing deterioration of function. Co-existing infection or Impactedstones.

PROCEDURES:

For stone in upper third ureter:

- **ESWL** (ideal approach)
- **URS**- ureterorenoscopic stone removal
- Open **Ureterolithotomy** vialoin incision

For stone in middle third ureter:

- URS
- Open Ureterolithotomy

For stones lower third of ureter

- *URS*
- *Dormia basketing*
- *Open ureterolithotomy*
- *Ureteric meatotomy*

Urinary Calculi- Biochemical Tests

OXALATE (Calcium Oxalate)Stone

- Also called Mulberry stone
- Covered with sharp projections
- Sharp makes kidney bleed (haematuria)
- Very hard
- Radio – opaque
- Under Microscope looks like Hourglass or Dumbbel shape if monohydrate & like an envelope if Dihydrate.

BIOCHEMICAL Test

Procedure-

- Make fine powder of stone
- Add 2 to 3 drops of 10% Hcl
- Cool it and add pinch MnO_2- do not mix

Result: formation of gas bubbles form bottom

Urinary Calculi- Biochemical Tests

Phosphate Stone

- Usually Calcium phosphate
- Sometimes calcium magnesium ammonium phosphate or triple phosphate
- Smooth
- Minimum symptoms
- Dirty white
- Radio – opaque
- Calcium phosphate also called Brushite appears like Needle shape under microscope

Calcium Phosphate Stone

IN ALKALINE URINE

↓

ENLARGES RAPIDLY

↓

TAKE SHAPE OF CALYCES

↓

STAGHORN→

Urinary Calculi- Biochemical Tests

Biochemical Test for Phosphate Stone

Procedure:

- Make fine powder of Stone
- Add o.5ml of Ammonium molybdate
- warm over a gas flame

Result:

- Formation of yellow precipitate.

Urinary Calculi- Biochemical Tests

Uric Acid & Urate Stone

- Hard & smooth
- Multiple
- Yellow or red-brown
- Radio - lucent (use ultrasound)

- pKa of Uric acid 5.75 at this pH 50% of Uric Acid Insoluble. If pH falls further- Uric acid more insoluble.

BIOCHEMICAL Test-Murexide test

Procedure:

- Make fine powder of the stone by using mortor
- Take a pinch of the powder in a test tube
- Add 1drop of 20g/dl Na_2Co_3.
- Add 2drops of phophotungstic acid reagent

Result : formation of deep blue color.

Clinical significance: gout

Urinary Calculi- Biochemical Tests

Cysteine Stones

- Autosomal recessive disorder
- Usually in young girls
- Due to cystinuria –Cystine not absorbed by tubules
- Multiple
- Soft or Hard – can form stag-horns
- Pink or yellow
- Radio opaque

Under microscope appears like hexagonal or benezene ring – ask for first morning sample

Urinary Calculi-Biochemical tests

Biochemical Test for Cysteine Stone

Procedure:

- Make fine powder of Stone
- Add 1drop of Ammonium hydrooxide reagent and one drop of NaCl reagent, wait for 5min
- Add 2-3 drops of sodium nitroprussidereagent

Result:

Beet red color changes to orange is standing

Clinical significance: Cystinuria


Thank you