Identification and Qualitative Analysis of Renal Calculi

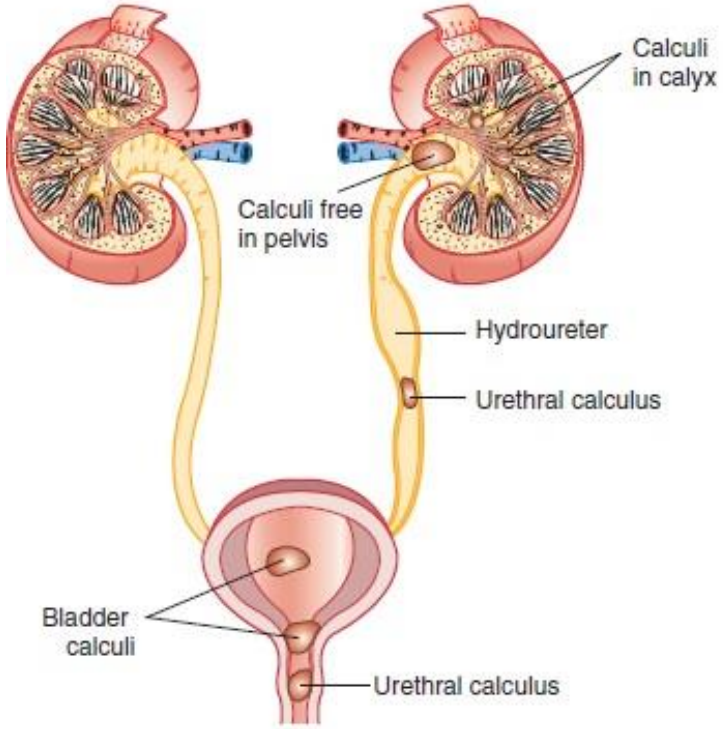
-Renal Calculi:

- **Kidney stones** , **renal calculi** or **renal lithiasis** (stone formation) are small, hard deposits that form in the urinary system.

- The stones are made of **mineral** and **acid salts**.

- Kidney stones have many causes and <u>can affect any part of your urinary tract</u> (kidneys, ureters, bladder, and urethra).

- It is a common cause of **blood** in the urine and **pain** in the abdomen, flank, or groin.



Pathogenesis of renal stones :

- There are two basic aspects in the pathogenesis of renal stones:

1. Increased urinary excretion of stone forming elements: like calcium, phosphorus, uric acid, oxalate, and cysteine.

2. Low fluid intake: a low fluid intake results in the production of **concentrated urine**, causing super-saturation and crystallisation of stone-forming compounds. (In addition, low urine flow rates favour crystal deposition on the urothelium).

➔**Note:** Cystine stones formed only when its concentration increased in the urine.

- **Other: Physio-chemical changes which influence stone formation like:** pH of urine, stone matrix, and protective substances in the urine.

- Risk factors:

1. Low fluid intake:

The single most important determinant of stone formation is low fluid intake. A low fluid intake results in the production of concentrated urine.

2. High salt diet.

3. Repeating, or recurrent, urinary tract infections.

4. Blockage of your urinary tract.

-Investigation of Renal Calculi:

1- Urine analysis and Urine culture:

-It may show crystals, red blood cells, and/or pus cells in urine.

2- Stone analysis:

1.Chemical analysis of stones (simple test but is not an accurate).

2.Crystallography (better method).

3- Biochemical investigations:

-**Serum** calcium, phosphorus, uric acid, and renal function tests.

-**24 hour urine** for calcium, phosphorus, uric acid, oxalate, citrate, and cystine.

-Investigations for special clinical situations like **hyperparathyroidism, gout**, should also be included.

- **The main objectives in investigation are to find out :**

1. The composition of stones.
2. Cause of stone formation.
3. Functional status of kidney.
4. Presence/absence of obstruction in urinary tract.
5. Evidence of possible urinary infection.

-Types of Calculi :

- There are four basic types of kidney stones :

1. Calcium stones ➔ calcium oxalate and calcium phosphate.
2. Uric acid stones.
3. Struvite stones (magnesium ammonium phosphate), also known as **triple phosphate stone**.
4. Cystine stones.

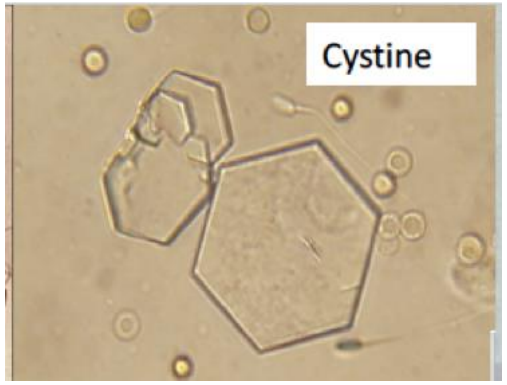
- **Most kidney stones (70% to 80%) are calcium stones** – calcium oxalate, calcium phosphate, or a combination of the two materials.

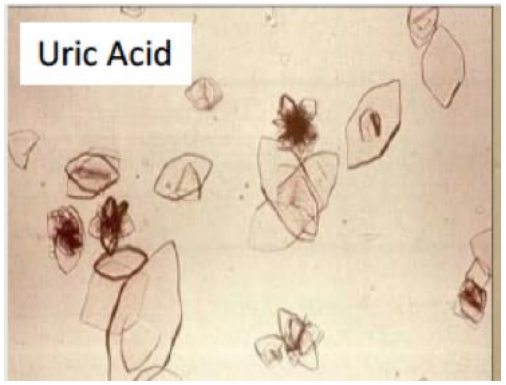
- A patient can have one or a combination of these stones.

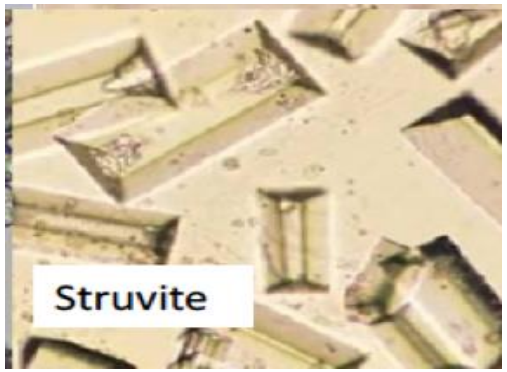
-Types of Calculi :

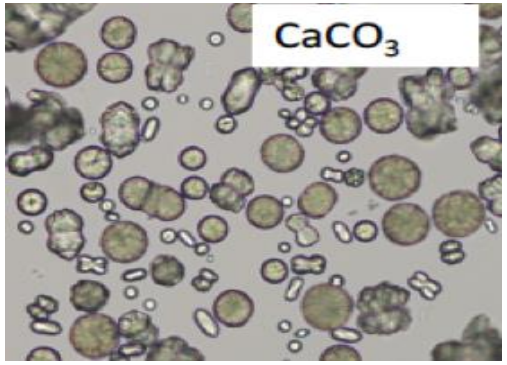
Stone type and composition	Contributing factors	Notes
Calcium stones **1.** Calcium oxalate. **2.** Calcium phosphate.	• Hyperparathyroidism. • Hypercalcemia and Hypercalciuria. • Hyperoxaluria. (some food eg. spinach, strawberries and large doses of Vitamin C may increase the amount of oxalate in your urine). • Vitamin D toxicity.	• **Calcium oxalate** stones are more common. • **Calcium phosphate** stones are caused by the combination of high urine calcium and **alkaline urine** (because phosphate level increase in alkaline urine). • **Carbonate apatite** is one kind of calcium phosphate stones, and commonly consider as infection marker.
Uric acid stones (Urate**)**	• Form in acid urine with pH around 5. • Gout. • High purine diet. • Excessive urinary uric acid.	• Can treated by: - Increase fluid intake. - Alkalinization of the urine.
Struvite stones (magnesium ammonium phosphate stones**)**	• Urea-splitting urinary tract infection UTIs (Some urinary bacteria can split the urea in urine to form ammonium and also to make urine less acidic).	• They can also be called **infection stones** if they occur with urinary tract infections (UTIs). • Can treated by: - Increase fluid intake. - Acidification of the urine
Cystine stones	• Develop in patients with cystinuria (inherited disorder).	• Less common. • Can treated by: - Increase fluid intake. - Alkalinization of the urine.

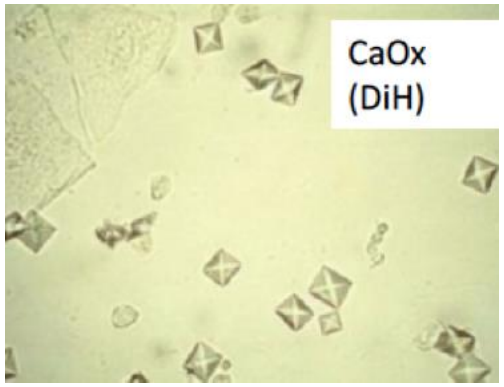
Stones crystals shape

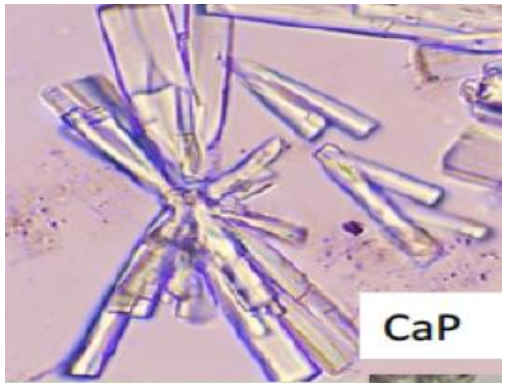


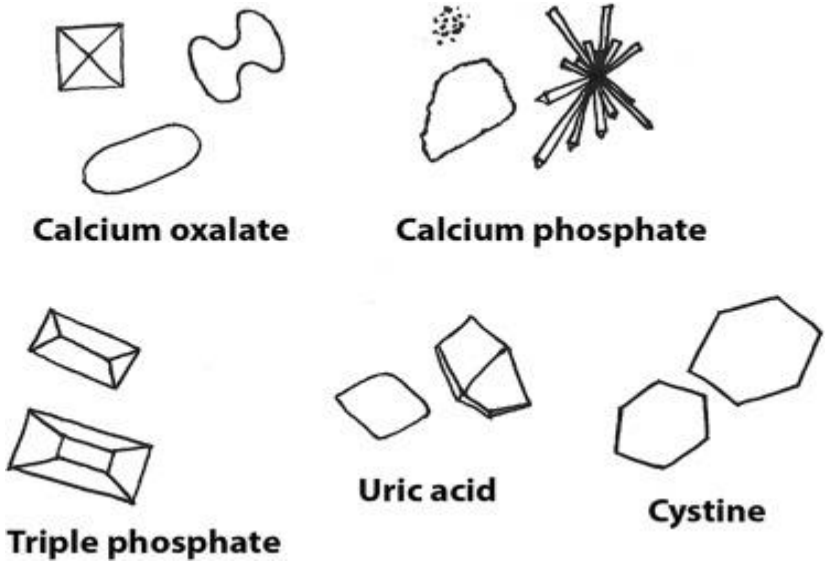












Practical Part

Objective:

- Identification and qualitative analysis of renal calculi.

General Principle:

- Each test based on the chemical properties of the stone-forming substance.

Experiments:

1.Test for uric acid.

2. Test for carbonate.

3. Test for oxalate.

4. Test for phosphates.

5. Test for calcium.

6. Test for magnesium.

(1) Test for Uric acid :

- **Principle:**

Uric acid undergoes oxidation when treated with HNO_3.

- **Method**:

1-Take a small amount of the sample.

2-Add 5-7 drops of concentrated nitric acid (Carefully).

3- Heat in a water bath.

➔ (The positive result is yellow to orange color on the inner surface of the test tube)

(2) Test for carbonate :

- **Principle:**

$2\ HCl + CaCO_3 \Longrightarrow CaCl_2 + H_2O + \mathbf{CO_2}$

- **Method:**

1- Add 0.5 ml con. hydrochloric acid to a small portion of the sample (Carefully).

➔ (Gas bubbles will indicate the presence of carbonate).

(3) Test for oxalate:

- **Principle:**

In sulfuric acid solution, oxalate combines with hydrogen to form oxalic acid.

$$2\,MnO_4^- + 5\,H_2C_2O_4 + 6\,H^+ \rightleftharpoons 2\,Mn^{2+} + 10\,CO_2 + 8\,H_2O$$

Purple color — oxalic acid — colorless

- **Method:**

1- Heat a part of the sample with 2 ml diluted sulphuric acid (2M H_2SO_4) for 1 min.

2-Add 2 drops (one by one) of potassium permanganate ($KMnO_4$) solution and mix.

➔ (The decolonization of potassium permanganate will confirm the presence of oxalate).

(4) Test for phosphates:

- **Principle:**

Phosphate ions react with ammonium molybdate to produce a characteristic yellow precipitate of ammonium phosphomolybdate.

- **Method:**

1- Dissolve a little of the sample in about 1.5 ml of concentrated nitric acid HNO_3.

2- Add an equal volume (1.5 ml) of ammonium molybdate solution.

3- Heat to boiling water bath.

➔ (If phosphates are present, a yellow precipitate of ammonium phosphomolybdate is obtained).

(5) Test for calcium :

- **Principle:**

Calcium is precipitated as calcium oxalate using ammonium oxalate.

- **Method:**

1- Dissolve small amount of the sample by heating with 2 ml dilute hydrochloric acid (2M HCL).

2- Add 1 ml ammonium oxalate.

➔ (A white precipitate of calcium oxalate shows the presence of calcium).

(6) Test for magnesium :

- **Principle:**

The combination between titan yellow and **magnesium hydroxide** to produce an orange colour.

- **Method:**

1- On a few amount of magnesium, add 1ml of titan followed by 1 ml potassium hydroxide (to be strongly alkaline).

➔ (An orange to red color indicates the presence of magnesium).

-Results:

Component	Observation	Type pf stone/s
Uric acid		
Carbonate		
Oxalate		
Phosphate		
Calcium		
Magnesium		

-Discussion:

- Comment in each results you obtained and mention whether the sample contains these component or not?
- What type of stone can be formed by each substance.
- What the disease that cause each type of stone.
- Explain the causes.

References:

- Pooler C. Porth Pathophysiology: Concepts of Altered Health States. Lippincott Williams & Wilkins. 2009. p. 699.
- Hesse A. Urinary Stones: Diagnosis, Treatment, and Prevention of Recurrence. Karger Medical and Scientific Publishers, 2009. p.86.
- National Cancer Institute (NCI): http://www.webmd.com/kidney-stones/tc/types-of-kidney-stones-topic-overview
- Medical Aspects of Renal Stones, REVIEW ARTICLE, KK Malhotra,2008.