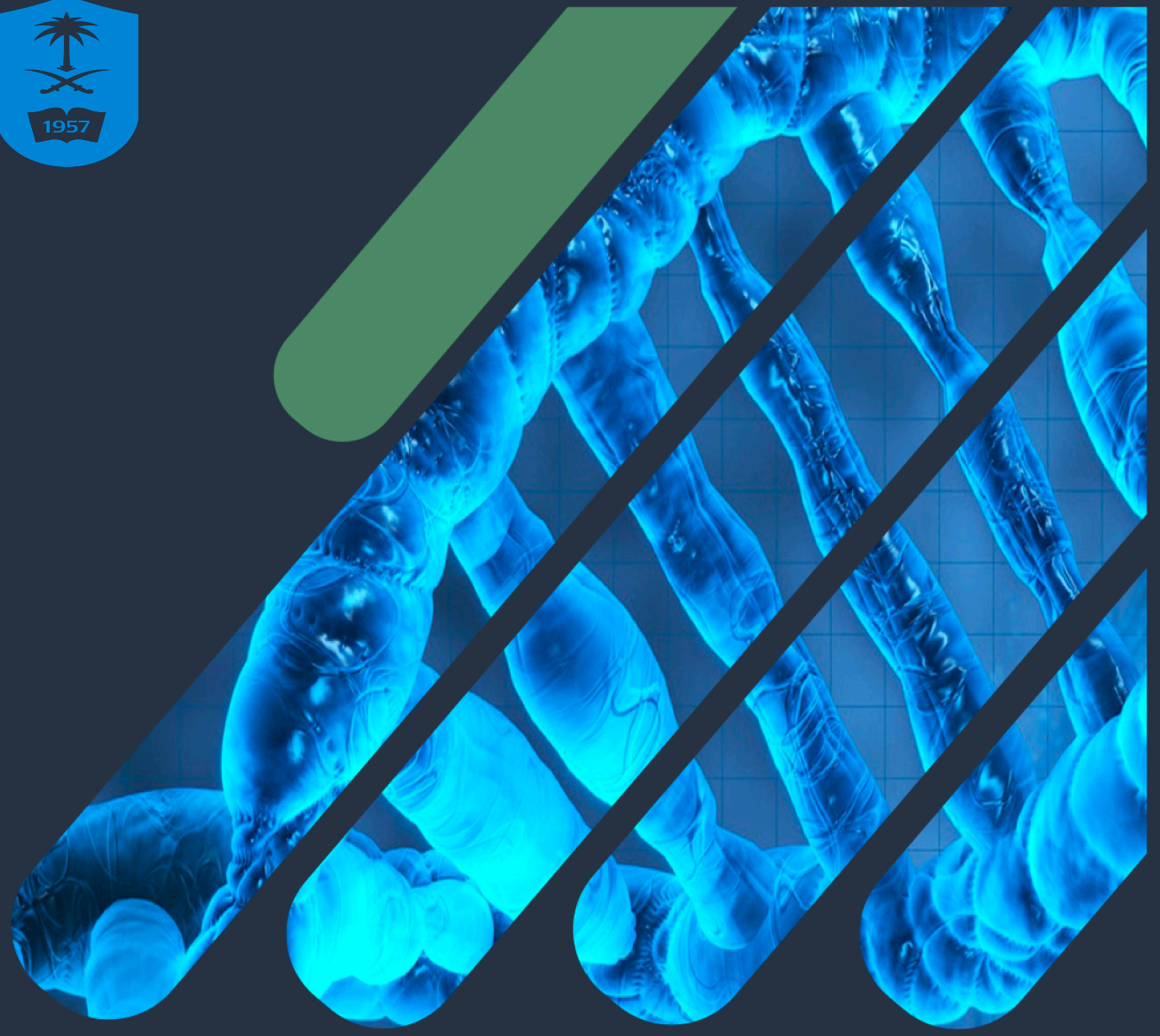
Biochemistry

Kidney Stones



When life puts you in tough situations, don't say WHY ME Say TRY ME ..

Revised by
شوق الأحمري & طراد الوكيل

- Important.
- Doctors notes.
- Doctors slides.

Biochemistry team 436

OBJECTIVES:

By the end of this lecture the students will be able to:

- Discuss the general physiological and pathological factors that favor kidney stones formation.
- List the types of kidney stones, their chemical constituents and characteristics.
- Identify the etiological causes of each type of kidney stone.
- Discuss the diagnosis, treatment and prevention of kidney stones

Kidney Stones

What are kidney stones ?

Renal calculi (kidney stones) are formed in renal tubules, ureter or bladder.

Composed of metabolic products present in glomerular filtrate.

These products are in high concentration

Near or above maximum solubility.

الماكسيموم سوليبيلتي ممكن نشبهها بكأس الماء إذا ذوبنا فيه كمية كبيرة من الملح، بحيث الملح راح يذوب
حتى يوصل درجة معينة يصير فيها يتراكم ولا يذوب ، لأن الماء تشبع منه .

In which conditions do they form ?

1. High concentration of metabolic products in glomerular filtrate.
2. Changes in urine pH.
3. Urinary stagnation (stasis)
4. Deficiency of stone-forming inhibitors in urine.

Some drugs and bacteria causes the changes in urine PH ..

If we have a glass of water and we kept adding salt (sodium) to it. The water will reach a limit which cannot accept any salt and accumulate at the bottom of the glass.

Conditions Causing Kidney Stone Formation

1. High concentration of metabolic products in glomerular filtrate *is due to*

- Low urinary volume (with normal renal function) due to restricted fluid intake
- Increased fluid loss from the body due to excessive sweating or diuretics
- Increased excretion of metabolic products forming stones. (urinary system is exposed to more metabolites)
- High plasma volume (high filtrate level) Filtration increases thus metabolite amount in filtrate increase too .
- Low tubular reabsorption from filtrate .

(urine will more concentrated)

2. Changes in urine pH due to

- **Bacterial infection**
  It could be acid or base depending on the type of bacteria
- **Precipitation of salts at different pH.**

3. Urinary stagnation is due to

- **Obstruction of urinary flow.**

- If urine PH has changed, some substances become insoluble because certain substances are soluble at certain Ph.

We should determine the Ph of the urine for treatment:

1. Acidification
2. alkalization

Conditions Causing Kidney Stone Formation

4. Deficiency of stone-forming inhibitors

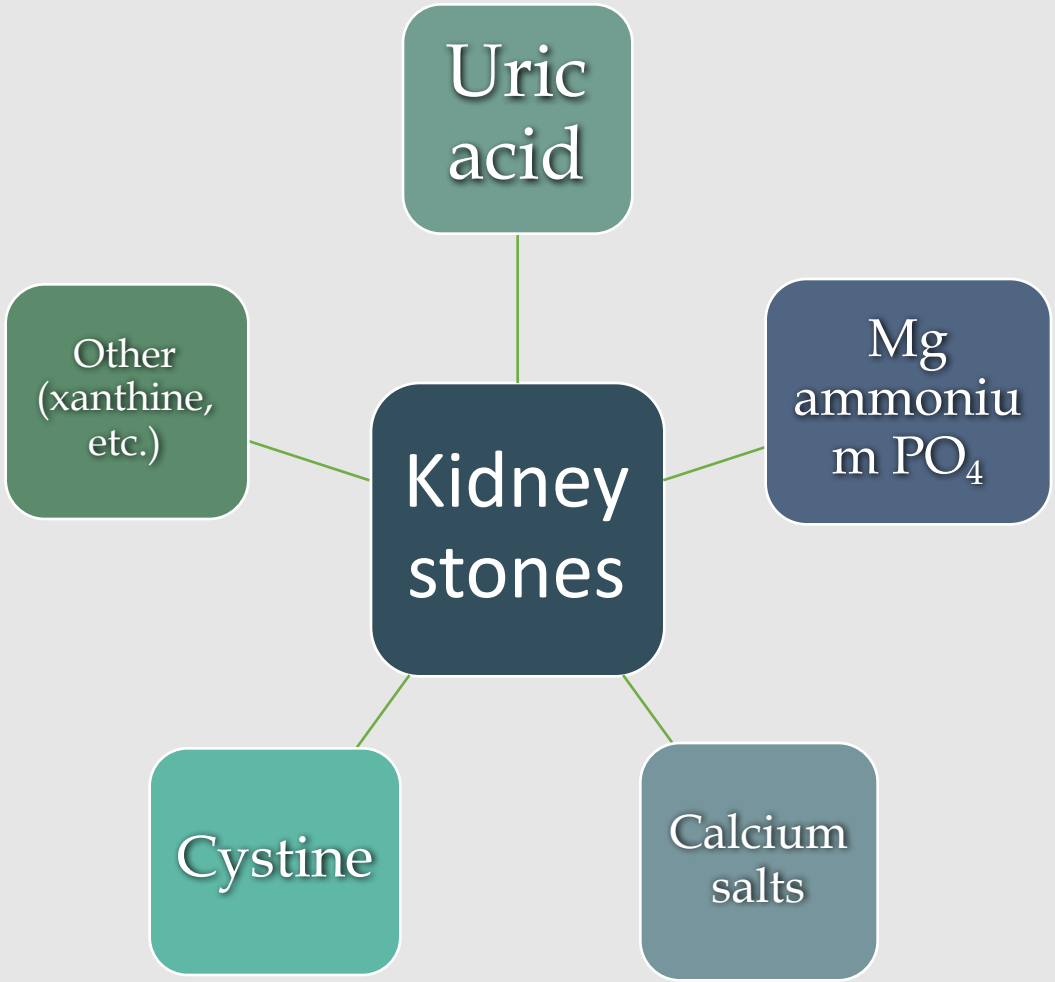
Urine contains substances that function to protect the possibility of pathological calcification in tubular fluid and urine

Citrate, pyrophosphate, glycoproteins inhibit growth of calcium phosphate and calcium oxalate crystals .

In type I renal tubular acidosis, hypocitraturia leads to renal stones.

hypocitraturia is citrate excretion of less than a certain amount per day..

Types Of Kidney Stones



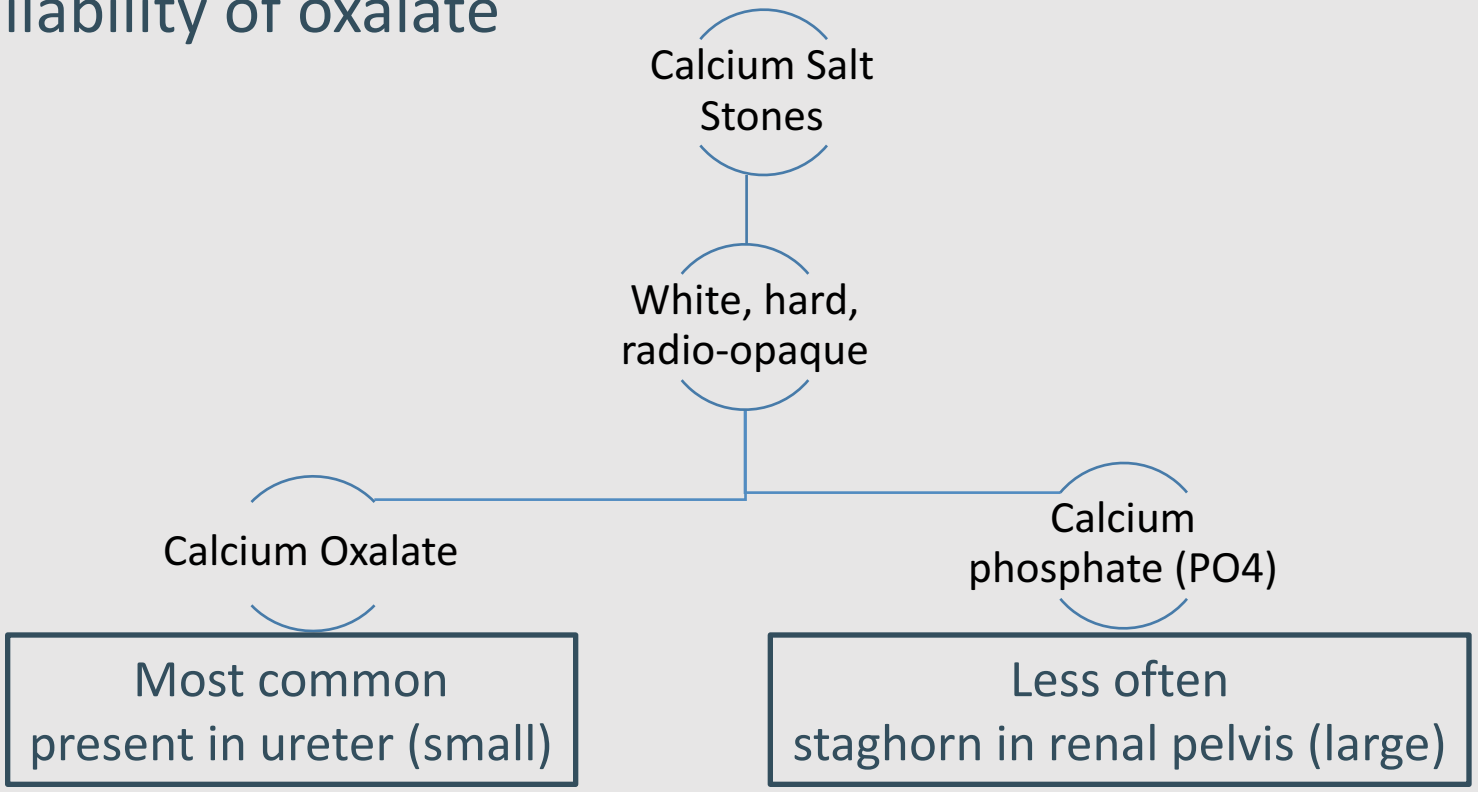
TYPE	PH level at which stones are formed	Appearance on X-ray
Calcium salts	Alkaline urine	radio-opaque
Need high pH to form stones		
Uric acid	Acidic urine	Radio-lucent
Need low pH to form stones		
Mg Ammonium Po4	Alkaline urine	Faint radio-opaque
Need high pH to form stones		
Cystine	Acidic urine	Faint radio-opaque
Need low pH to form stones		
Xanthine	Acidic urine	Radio-lucent
Need low pH to form stones		

Calcium Salt Stones

- ✓ 80% of kidney stones contain calcium
- ✓ The type of salt depends on:

1. Urine PH
2. Availability of oxalate

- Most common type.
- Ca is a cation, so it combines with an anion (e.g. oxalate, phosphate) to form salts.



Calcium Salt Stones

CAUSES OF CALCIUM SALT STONES

Hyperoxaluria

- Also known as secondary hyperoxaluria.

❖ **Causes:**

- the formation of calcium oxalates with or without hypercalciuria.

Oxalate and calcium are highly attractive. The two bind together rapidly even without Hypercalciuria.

- Increased oxalate absorption in fat malabsorption.
- **Occurs due to:**

diet rich in oxalates (e.g. tomatoes).

Hypercalciuria

- Increased urinary calcium excretion.
- **Men:** > 7.5 mmols/day
- **Women** > 6.2 mmols/day
- May or may **not** be due to hypercalcemia (**often due to primary hyperparathyroidism**)
- **Sometimes, Ca++ salts stones are found with no hypercalcemia**.

but they are commonly found together

Hypercalciuria can occur due to increased bone resorption without Hypercalcemia.

Primary hyperoxaluria

- **Due to** inborn errors.
- **Urinary oxalate excretion:** > 400 µmols/day

This disease causes inability to metabolize oxalate, increasing its concentration in the serum.

Secondary is exogenous: from diet

Fat malabsorption results in fat reaching the colon. This fat will bind to calcium (which is usually binds to oxalate and get excreted in stool) releasing free oxalate which ultimately will be reabsorbed into the blood. Therefore, increasing oxalate in the blood.

Calcium Salt Stones

❖ Calcium salt stones are formed in alkaline urine

Treatment

- **Treatment of primary causes**
  - such as infection, hypercalcemia, hyperoxaluria
- **Oxalate-restricted diet**
  - Because it's not recommended to reduce Ca in the diet
- **Increased fluid intake**
  - First we must check his glomerular function .. (to prevent overload)
- **Acidification of urine (by dietary changes)**

Staghorn قرن الأيل

Uric Acid Stones

- Represent about 8% of renal stones contain uric acid
- May be associated with hyperuricemia (with or without clinical gout)
- Form in acidic urine (Unlike calcium stones)

General Appearance

- Small, friable, yellowish
- May form staghorn (If it was big)
- Radiolucent (plain x-rays cannot detect)
- Visualized by ultrasound or I.V pyelogram

Treatment

- Purine-restricted diet
  - Because it's the origin of Uric acid
- Increase fluid intake
- Alkalization of urine (by dietary changes)
- Treat the cause of hyperuricemia

Mg Ammonium PO4 Stones

- Represent about 10% of all renal stones contain Mg amm. PO4
- Also called struvite kidney stones
- 75% of staghorn stones are of struvite type
- Commonly associated with chronic and upper urinary tract infection and staghorn calculi .

Mg ammonium PO4 is kind of mineral that naturally found in the earth. Its geological name is "struvite"

Treatment

- Treatment of infection
- Urine acidification
- Increase fluid intake
- In some cases, it may require complete stone removal (percutaneous nephrolithotomy)

Chronic urinary tract infection

Caused by Microorganisms (such as from Proteus genus) that has urase activity which metabolizes urea into ammonia.

Causing urine pH to become **alkaline** leading to stone formation

- **Infection is prime factor to struvite stones**
- **Bacterial infection leads to 2 things:**

1. **Urease activity**
2. **Change to alkaline pH**

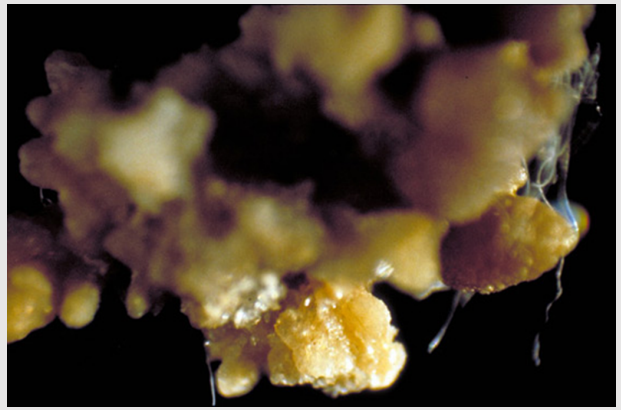
These two are the factors leading to Mg stone formations.

Cystine Stones

- A rare type of kidney stone.
- Due to homozygous cystinuria.

(Inborn error of amino acid metabolism; It might be genetic)

- Form in acidic urine.
- Soluble in alkaline urine.
- Faint radio-opaque.

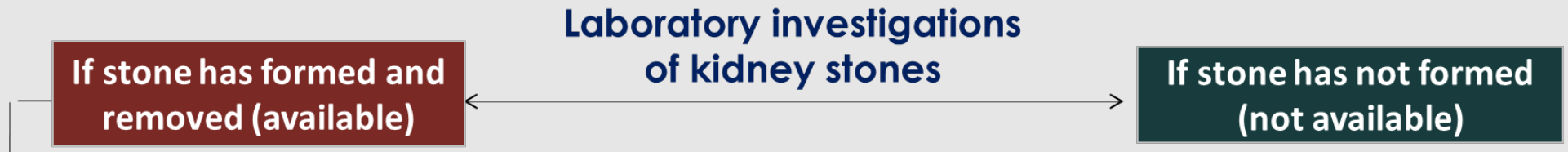


Treatment

- ✓ Increased fluid intake
- ✓ Alkalization of urine (by dietary changes)
- ✓ Penicillamine (binds to cysteine to form a compound more soluble than cystine)

Cystine doesn't exist normally in our body, it is formed due to oxidization of two cysteine (amino acid) molecules leading to formation of the insoluble cystine molecules which will eventually lead to cystine stones formation (important to understand treatment only)

Laboratory Investigations Of Kidney Stones



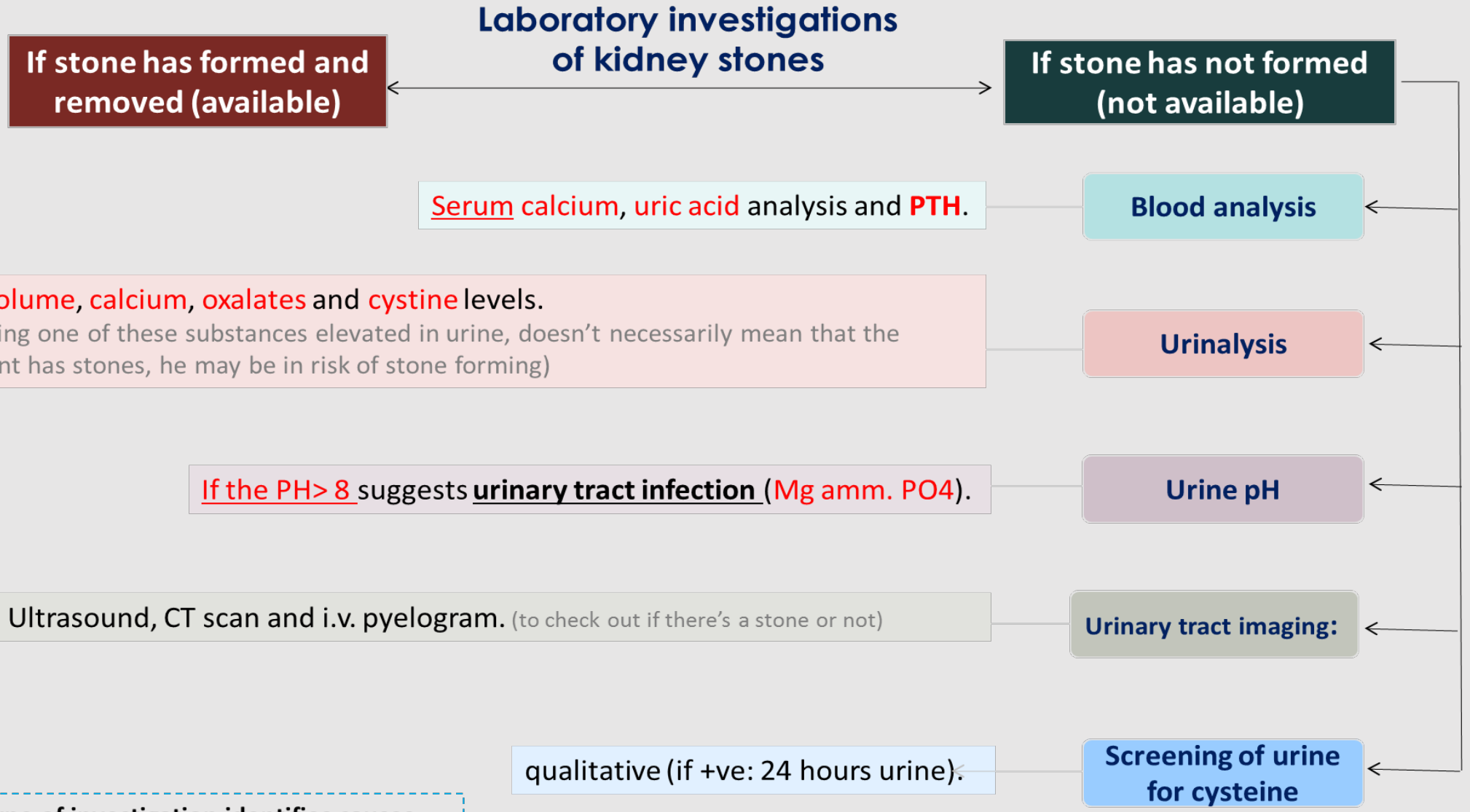
❖ **Chemical analysis of stone obtained from(urine or by surgical intervention) helps to:**

- Identify the cause.

- Advise patient on prevention and future recurrence

If the stones are removed (available – موجودة في يد المريض أو الدكتور), we can analyze them to know their type and therefore the cause, and since the cause is known now, we can plan a conservative line treatment to prevent the recurrence of the stones (e.g. if it was because of an infection we should treat that infection first).

Laboratory Investigations Of Kidney Stones



This type of investigation identifies causes that may contribute to stone formation

TEAM MEMBERS

مهند الزهراني

صالح التويجري

TEAM LEADERS

- Rania Alessa
- Mohammad Almutlaq

THANK YOU

PLEASE CONTACT US IF YOU HAVE ANY ISSUE

- Review the notes

- Lippincott's Illustrated Reviews: Biochemistry, 6th E

- @436Biochemteam

- Biochemistryteam436@gmail.com

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