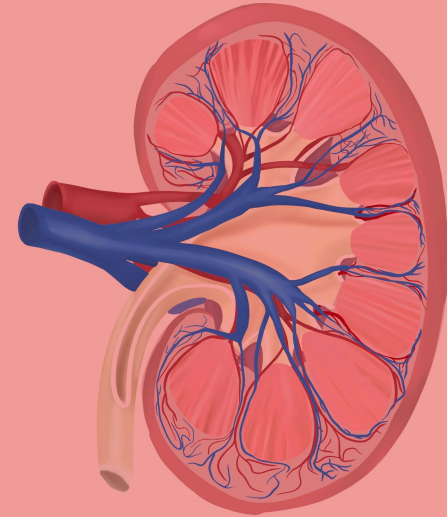


Kidney stones



Color index :





Main text

IMPORTANT

Extra Info

Drs Notes

Objectives:

-  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

"Renal calculi"

► Location of formation :

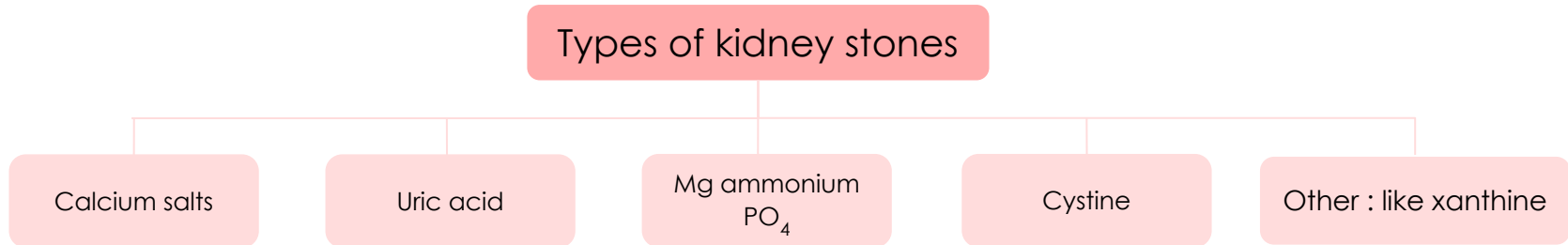
- renal tubules
- ureter
- bladder

usually kidney stones form in your kidney then move into ureter and bladder.

► Composition: metabolic products present in **glomerular filtrate**. "urea, creatinine and electrolytes"

► Concentration of the products forming kidney stones: **near or above maximum solubility (high)** .

When you add one spoon of sugar into a glass of water the sugar will dissolve, here the sugar is the solute and the water is the solvent. Now, if you continue to add the solute without limitation , you will reach a point that solvent can't dissolve more solute, this point called **maximum solubility** so the solute starts to precipitate and this is the first step to form kidney stones



Conditions causing kidney stone formation

1- High conc. of metabolic products in glomerular filtrate due to:

A) Increase in the amount of molecules (the volume "water " is constant)

- Increase the excretion of metabolic products forming stones.
- increase in plasma volume (high filtrate level) leads to decrease in tubular reabsorption from filtrate (accumulation of molecules in the kidney).

B) Decrease in volume " water " (the amount of molecules are constant)

- Low urinary volume (with normal renal function) due to restricted fluid intake.
- Fluid loss from the body e.g. sweating, this eventually leads to low urinary volume.

2- Changes in urine pH normal range(5.5 - 6.5) due to :

A) Alkaline urine (↑ pH more than 7)

- **Due to:** Upper urinary tract **infection** .
- **Promotes:** Mg Ammonium Phosphate "Mg ammonium PO₄" crystals (Struvite stones).
alkaline urine can be due to change of diet like eating so much fruit and vegetables and also some drugs

B) Acidic urine (↓ pH)

- **Due to :** acidosis and diabetic ketoacidosis.
- **Promotes:** Uric acid precipitation.
Acidic urine can be due to change of diet like increase in meat consumption, and also some drugs

C) Bacteria Infection

Most of the bacteria responsible for urinary tract infections make the urine **more alkaline** because the bacteria split urea into ammonia and other alkaline waste products.

3- Urinary stagnation "زكود" due to :

obstruction of urinary flow.

4- Deficiency of stone-forming inhibitors due to :



stone-forming inhibitors are substances that present normally in the urine to inhibit stone formation by different mechanisms

Inhibitors of calcium phosphate and calcium oxalate crystals:


- Citrate (In type I renal tubular acidosis , **hypocitraturia** leads to renal stones) .
hypocitraturia caused either by failure to reabsorb bicarbonate or by insufficient secretion of hydrogen ions
- Pyrophosphate.
- Glycoproteins.

Calcium salt stones


(common type of kidney stones)

Overview	<p>80% of kidney stones contain calcium: there are two type:</p> <ol style="list-style-type: none">1- Ca-Oxalate (most common).2- Ca-Phosphate (less common).	
depends on	<ol style="list-style-type: none">1- Urine pH (ca-phosphate tends to form in alkaline urine, whereas ca-oxalate doesn't really depend on pH).2- Availability of oxalate (oxalate has high binding capacity to calcium).	
General appearance	<ul style="list-style-type: none">– White, hard, radio-opaque (radio-opaque means it is visible in X-ray photograph).– Calcium oxalate: present in ureter (small).– Calcium PO₄: staghorn calculi especially in renal pelvis (large). <p>(Staghorn calculi refer to branched stones that fill all or part of the renal pelvis and branch into several or all of the calyces)</p> <div style="display: flex; justify-content: space-around; align-items: center;"><div style="text-align: center;"><p>Calcium oxalate</p></div><div style="text-align: center;"><p>Calcium PO₄</p></div></div>	
Causes	<p>Hypercalciuria (considered the main cause)</p>	Increased urinary calcium excretion (impaired renal tubular reabsorption) . so in men will be more than 7.5 mmols/day , and in women more than 6.2 mmols/day.
	<p>Hypercalcemia</p>	<ul style="list-style-type: none">– Hormonal cause (most often due to primary hyperparathyroidism) which cause bone resorption, thus raising the blood calcium level. It is also due to increase calcium absorption in GIT or decrease in kidney reabsorption.– sometimes, Ca⁺⁺ salts stones are found with no hypercalcemia such as when you have high concentration of oxalate.
	<p>Hyperoxaluria</p>	<p>(Causes the formation of calcium oxalates without hypercalciuria) as a result of:</p> <ul style="list-style-type: none">– Diet rich in oxalates E.g. tomatoes , spinach and figs.– Increased oxalate absorption in fat malabsorption. Normally, after oxalate is formed, it combines with calcium to be excreted in the stool. When large amounts of unabsorbed fat are available -e.g. from fat malabsorption which happens because of damage to the intestine from infection, inflammation, trauma, or surgery - calcium preferentially binds to fat instead of oxalate. So in this case oxalate in the urine is elevated).- Note that oxalate has high binding capacity to calcium -
	<p>Primary hyperoxaluria</p>	Due to inborn errors of metabolism resulting in increased endogenous production of oxalate leading to excessive urinary oxalate excretion: more than 400 mol/24 Hours
Treatment	<ul style="list-style-type: none">– Treatment of primary causes such as infection,hypercalcemia, hyperoxaluria .– Oxalate-restricted diet e.g : grains, fruit and vegetables .– Increased fluid intake (if there's no glomerular failure) to get rid of the stones .– Acidification of urine (by dietary changes e.g: meat), as we know calcium salt stones are formed in alkaline urine.	


Uric acid stones

Overview	<p>About 8% of renal stones contain uric acid.</p> <p>Uric acid is a product of the metabolic breakdown of purine nucleotides, uric acid is not very soluble so when pH below 5.5 then the chance of making Uric acid stones becomes higher .</p>
depends on	<p>1-Urine pH (in acidic urine, low pH).</p> <p>2-Meat consumption makes the urine more acidic while fruit consumption alkalizes the urine.</p>
General appearance	<p>– Small, friable(breaks easily), yellowish.</p> <p>– May form staghorn (if it's big) .</p> <p>– Radiolucent (plain x-rays cannot detect easily) it can't be seen normally on x-ray so it is visualized by ultrasound or i.v. pyelogram.</p> <p>IV-pyelogram (IVP) is an x-ray examination of the kidneys, ureters and urinary bladder that uses iodinated contrast material injected into veins, we use contrast to highlight urinary tract to see how the kidneys remove the dye and how it's been collected in urine</p> 
Causes	<p>– May be associated with hyperuricemia (with or without gout) it's not necessary to find gout with it.</p> <p>– Form in acidic urine.</p>
Treatment	<p>– Treatment of cause of hyperuricemia.</p> <p>– Purine-restricted diet because purine is a precursor of uric acid.</p> <p>– Alkalinization of urine (by dietary changes e.g: fruit and vegetables) as you know Uric acid stones tend to form in acidic urine.In severe cases we use I.V infusion of bicarbonate (base).</p> <p>– Increased fluid intake (common treatment in all kidney stones types).</p>

Mg ammonium PO₄ stones

Overview	<p>About 10% of all renal stones contain Mg ammonium PO₄. Also called struvite kidney stones . Struvite (magnesium ammonium phosphate) is a phosphate mineral that naturally found in the earth. Its geological name is struvite</p>
depends on	<p>Urine pH (in high pH which means alkaline urine).</p>
General appearance	<p>– Commonly associated with staghorn calculi. – 75% of staghorn stones are of struvite type.</p> 
Causes	<p>– Associated mainly with chronic urinary tract infection : Microorganisms (such as from Proteus genus). Proteus organisms tend to produce urease that alkalize the urine by metabolizing (hydrolyzing) urea into ammonia causing urine pH to become alkaline leading to stone formation.</p> <p>Proteus species commonly found as part of normal human intestinal flora. Urease, an enzyme that catalyzes the hydrolysis of urea, forming ammonia and carbon dioxide.</p> <p>Q1: A patient has staghorn stones with no UTI, what is the most likely type of stone? Calcium phosphate stone Q2: A patient has a staghorn shaped stone with UTI, what is the most likely type of stone? Struvite stone</p>
Treatment	<p>– Treatment of infection. – Urine acidification. – Increased fluid intake (doesn't help a lot in this type). – In some cases, it may require complete stone removal (percutaneous nephrolithotomy). more explanation about it here</p>

Cystine stones

Overview	<p>A rare type of kidney stone.</p> <p>cystine which is dipeptide formed from two cysteine molecules joined together .</p> <p>cystine is more stable than cysteine (cysteine is an amino acid), but may not be absorbed as well.</p>
depends on	<p>1- Urine pH (acidic urine , low pH).</p> <p>2- Diet which make the urine more acidic such as meat.</p>
General appearance	<p>– Yellow or light pink.</p> <p>– Soluble in alkaline urine.</p> <p>– Faint radio-opaque (is a type between radiopaque and radiolucent).</p> <p>Cystine calculi are said to be either radiolucent or radiopaque. However, most cystine stones are pure cystine and contain essentially no calcium. When compared to adjacent fluids and tissues, they are radiopaque because of their higher physical density and their higher effective atomic number</p> 
Causes	<p>1- Due to homozygous cystinuria which is an inherited autosomal recessive disease that is characterized by high concentrations of the amino acid cystine in the urine.</p> <p>2- Form in acidic urine.</p>
Treatment	<p>– Increased fluid intake.</p> <p>– Alkalinization of urine (by dietary changes) e.g: fruit, vegetables and milk.</p> <p>– Penicillamine (binds to cysteine -an amino acid- to form a compound more soluble than cystine).</p> <p>penicillamine is a breakdown product of penicillin, which was isolated from the urine of patients with liver disease who receive penicillin</p>

Lab investigations for kidney stones



If stone has **not** formed:

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

- Serum calcium, uric acid and PTH "parathyroid hormone" analysis. (hyperthyroidism leads to **hypercalcemia** → **hypercalciuria** → stone formation)
- Urinalysis: volume, calcium, oxalates and cystine levels.
- Urine **pH more than 8** suggests urinary tract infection which can lead to (**Mg ammonium PO₄** stones).

► Urinary tract imaging:

- CT scan.
- Ultrasound.
- I.V. pyelogram.



If stone has **formed** and **removed**:

► Chemical analysis of stone helps to:

- Identify the cause. by confirming the shape → type of stone → the cause
- Advise patient on prevention and future recurrence. Because if the person is a stone former, the chances of recurrence is quite high and can reach >50%

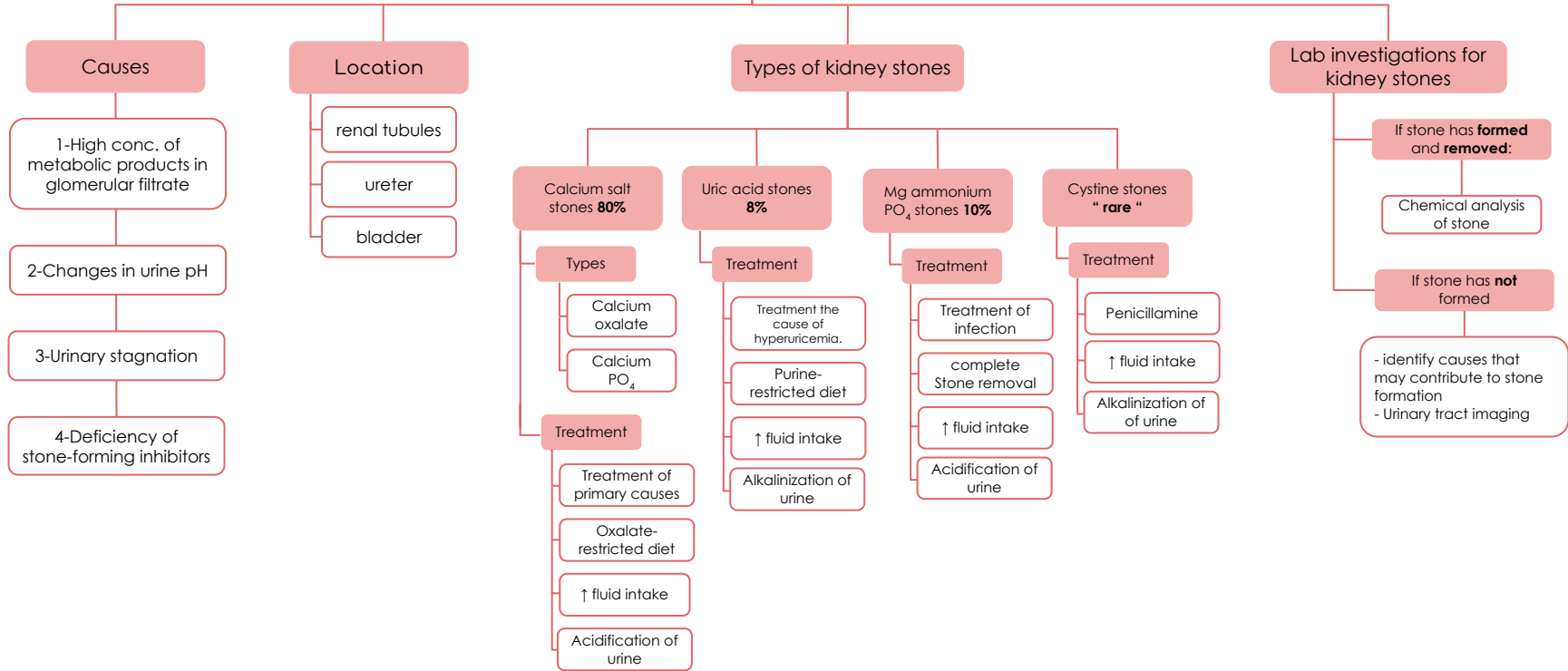


Summary of kidney stones

The type	Calcium salt stones	Uric acid stones	Mg ammonium PO ₄ stones	Cystine stones
Overview	<p>there are two type:</p> <ul style="list-style-type: none"> 1- Ca-Oxalate (most common) 2- Ca-Phosphate 	About 8% of renal stones contain uric acid	About 10% of all renal stones contain Mg ammonium PO ₄ Also called struvite kidney stones	A rare type of kidney stone
depends on	<ul style="list-style-type: none"> 1- alkaline urine for ca-phosphate 2- Availability of oxalate for ca-oxalate 	acidic urine	alkaline urine	acidic urine
General appearance	<ul style="list-style-type: none"> – White, hard, radio-opaque – Ca-oxalate: present in ureter (small) – Ca-PO₄: staghorn in renal pelvic (large) 	<ul style="list-style-type: none"> – Small, friable, yellowish – Radiolucent visualized by i.v. pyelogram .	associated with staghorn calculi	<ul style="list-style-type: none"> – yellow or light pink – Soluble in alkaline urine – Faint radio-opaque
Causes	<ul style="list-style-type: none"> Hypercalciuria hypercalcemia Hyperoxaluria Primary hyperoxaluria 	hyperuricemia	chronic urinary tract infection (such as from Proteus genus)	homozygous cystinuria
Treatment	Treatment of primary causes Oxalate-restricted diet Increased fluid intake Acidification of urine	Treatment of cause of hyperuricemia. Purine-restricted diet Alkalinization of urine Increased fluid intake	Treatment of infection Acidification of urine Increased fluid intake (percutaneous nephrolithotomy)	Increased fluid intake Alkalinization of urine Penicillamine

Summary

Kidney stones



Quiz

Q1 : Doctors usually do procedure called percutaneous nephrolithotomy in ?

- A) calcium salt stones B) uric acid stones C) Mg ammonium PO₄ stones D) cystine stones

Q2 : What's the concentration of products that forming kidney stones ?

- A)above maximum solubility B)below maximum solubility C) both A&B D) neither

Q3 : W hich type of kidney stones more associated with staghorn calculus ?

- A)calcium salt stones B) uric acid stones C)Mg ammonium PO₄ stones D) cystine stones


Q4 : What's the main cause of calcium salt stones ?

- A) hypercalciuria B) hyperoxaluria C) homozygous cystinuria D) proteus genus

Q5 : The doctor advised a patient to follow purine-restricted diet, the patient is more likely to have which type of kidney stones ?

- A)calcium salt stones B) uric acid stones C) Mg ammonium PO₄ stones D) cystine stones

Q6 : Proteus genus makes urine pH more?

- A)acidic B)alkaline C)neutral D) لا يكون تنتظرون اجي أعلمكم الجواب بعد؟ 

SAQs :

Q1: enumerate the conditions that causing kidney stones formation ?

Q2: enumerate the causes of calcium salt stones ?

Q3: what's the main cause of Mg ammonium PO₄ stones ?

Q4: if you become a doctor 😊 and a patient came to you complaining from pain , he had experienced a stone had formed in his kidney and removed, what you will do?

★ MCQs Answer key:

- 1) C 2) A 3) C 4) A 5) B 6) B


★ SAQs Answer key:

- 1) Check [slide 4](#)
- 2) Check [Slide 5](#)
- 3) Urinary tract infection (proteus genus).
- 4) 1-Chemical analysis of stone to identify the cause.
2-advise patient on prevention and future recurrence.

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