Biochemistry
Team 434

Kidney stones

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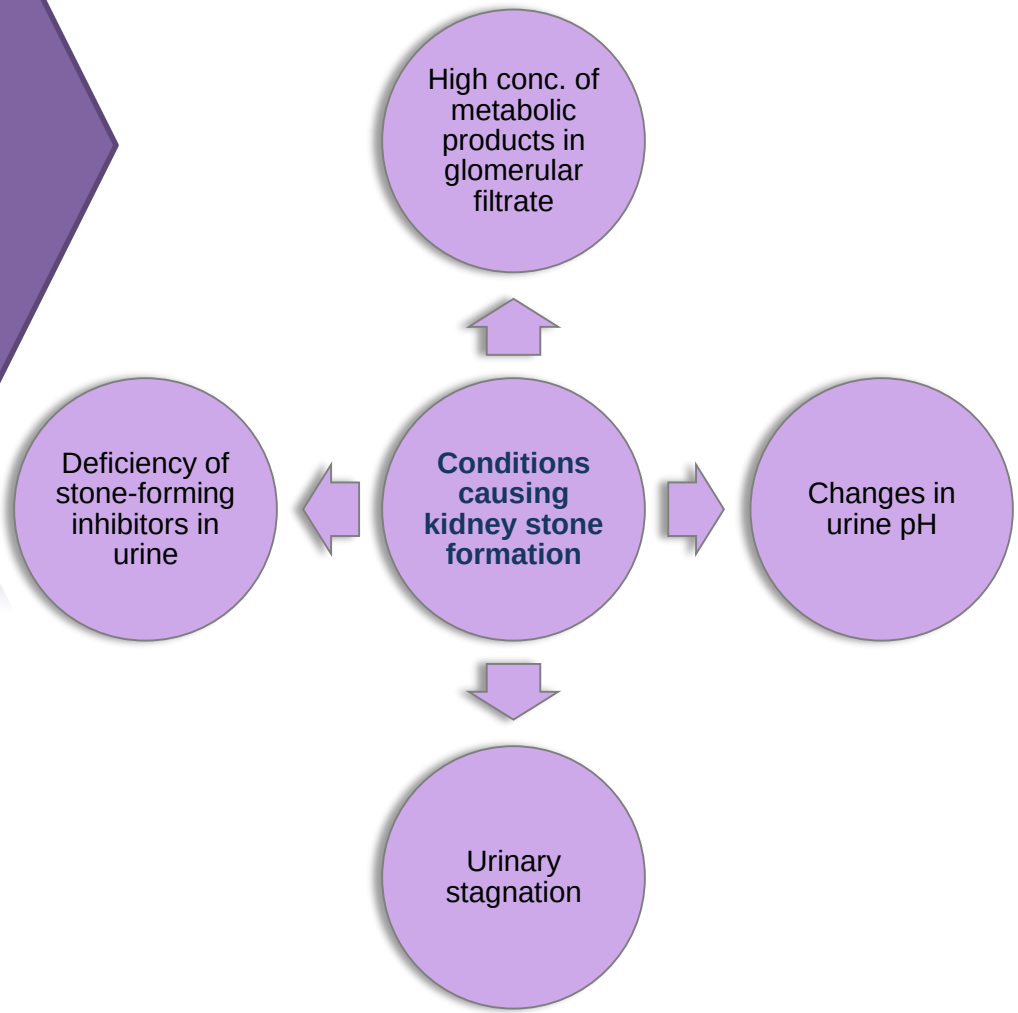
What are kidney stones?

(SATURATION)when metabolic products' concentrate they precipitate

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 conc.
Near or above maximum solubility.



High conc. of metabolic products in glomerular filtrate

(when their conc. Increases against normal fluid volume)

due to:

- Low urinary volume (with normal renal function)
  due to restricted fluid intake (e.g. person doesn't drink water)
- Increased fluid loss from the body (dehydration)
- Increased excretion of metabolic products forming stones (in this case your fluid volume is OK, but the problem is with increased metabolites)
- High plasma volume (high filtrate level>>more metabolites)
- Low tubular reabsorption from filtrate (metabolites remain>>increases their concentration)

Urinary stagnation

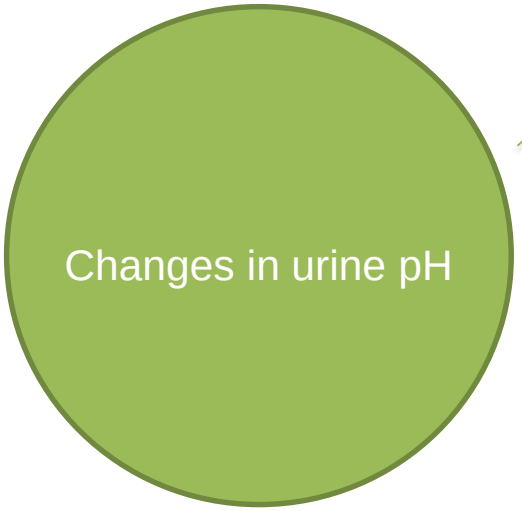
= solid state of urine

(blockage>>accumulation of urine will take place>>urine becomes concentrated>>stone formation)

due to:

- Obstruction of urinary flow

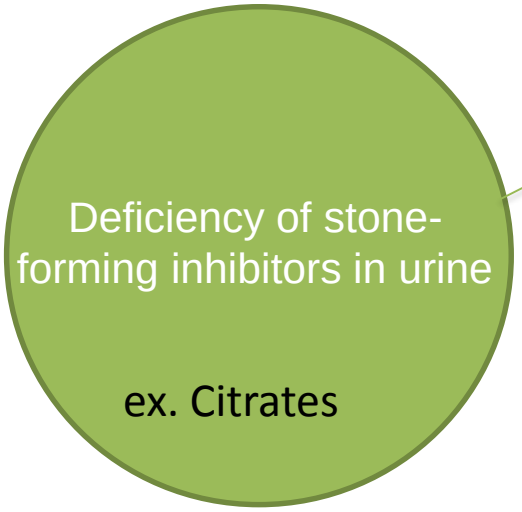
(medications or diet-dependent factor.some diet will make your urine alkaline whilst others makes it acidic.this is also applied upon medications)



Changes in urine pH due to:

- Bacterial infection (mostly to alkaline)
- Precipitation of salts at different pH (some prefer alkaline medium & others prefer acidic one)

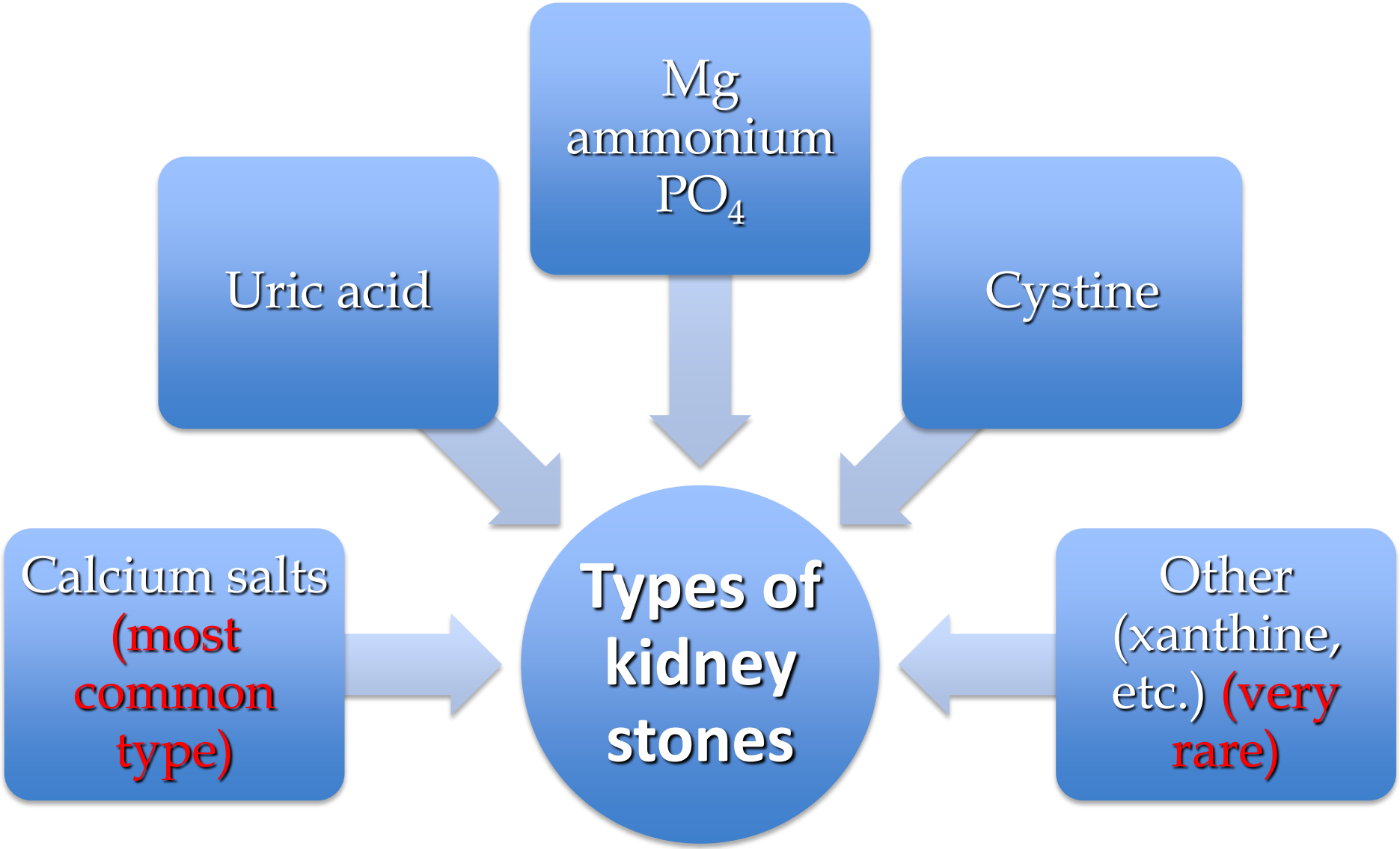
Hypocitraturia: a low amount of citrate in the urine, is an important risk factor for kidney stone formation.



(normally present chemicals inhibiting stone formation>>deficiency in these substanses>>stone)

Citrate, pyrophosphate, glycoproteins (these are all soluble si when ca binds to one of them it won't be precipitate)inhibit growth of calcium phosphate and calcium oxalate crystals

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


Mg ammonium PO_4
Uric acid
Cystine
Calcium salts (most common type)
Types of kidney stones
Other (xanthine, etc.) (very rare)

Calcium salt stones

80% of kidney stones contain calcium

The type of salt depends on
- Urine pH (as said before some salts are insoluble at certain pH while others are soluble at such pH)
- Availability of oxalate (the high you have oxalate the more the chance to get ca oxalate stone-type)

General appearance:
- White, hard, radio-opaque (dark=معتم)
- Calcium PO_4: staghorn (مرجانية الشكل) in renal pelvis (large)
- Calcium oxalate: present in ureter (small)

Note that : oxalate is much important constituent than Ca because some times we would have Ca stones with normal levels of Ca so calcium level can't be always used as an indicator. oxalate is more important

Treatment:

- Treatment of primary causes such as infection, hypercalcemia, hyperoxaluria
- Oxalate-restricted diet (no oxalate in diet, but at the same time No need to lower the ca level)
- Increased fluid intake (to decrease the concentration of some solutes)
- Acidification of urine (by dietary changes)
- Calcium salt stones are formed in alkaline urine
  - (give nitrogen-containing substances such as: protein, milk, beans)

causes of calcium salt stones:

Hypercalciuria: (high amount of ca in urine,with or without increased ca levels in serum)

- ليس من الضروري ان يكون الجسم يصنع الكثير من الكالسيوم قد يكون الخلل في زيادة اخراجه من الجسم نتيجة لحالة مرضية) Increased urinary calcium excretion (either because of high ca intake or increased bone resorbtion) Men: > 7.5 mmols/day Women > 6.2 mmols/day May or may not be due to hypercalcemia

Hyperoxaluria:

- Causes the formation of calcium oxalates without hypercalciuria. (oxalate is a stone-loving acid, binds to ca inducing ca-oxalate stone formation)
- Diet rich in oxalates (e.g. tomato,spinach, excess vit. C intake)
- Increased oxalate absorption in fat malabsorption (when fat is not absorbed, it will bind to ca & gets excreted. As a result oxalate accumulates & more chance to get this type of stones)

Primary hyperoxaluria:

- Due to inborn errors
- Urinary oxalate excretion: > 400 mmols/day

You don't have to memories the numbers

Uric acid stones

About 8% of renal stones contain uric acid

May be associated with hyperuricemia (with or without gout)

Form in acidic urine

General appearance:

- Small, friable, yellowish
- May form staghorn
- Radiolucent (transparent=شفاف) (plain x-rays cannot detect)
- Visualized by ultrasound or i.v. pyelogram

Treatment:

- Purine-restricted diet
- Alkalinization of urine (by dietary changes)
- Increased fluid intake

Mg ammonium PO_4 stones

(mostly staghorn appearance)

About 10% of all renal stones contain Mg amm. PO_4

Also called struvite kidney stones

Associated with chronic urinary tract infection (most common cause)

- Microorganisms (such as from Proteus genus) that metabolize urea into ammonia
- Causing urine pH to become alkaline and stone formation

(most infections make the urine Alkaline)

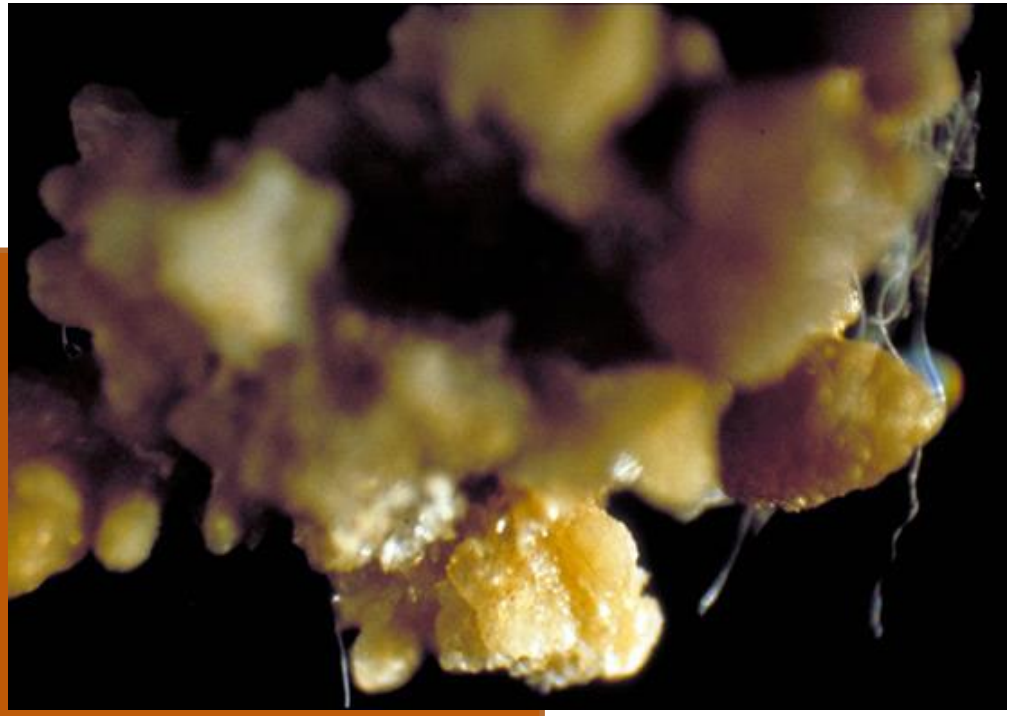
Commonly associated with staghorn calculi

75% of staghorn stones are of struvite type

Treatment:

- Treatment of infection
- Urine acidification
- Increased fluid intake

Cystine stones



Cystine is an amino acid
A rare type of kidney stone
Due to homozygous cystinuria
Form in acidic urine
Soluble in alkaline urine
Faint radio-opaque

Treatment:

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

Laboratory investigations of kidney stones

If stone has formed and removed:

If stone has not formed:

Chemical analysis of stone helps to:

- Identify the cause
- Advise patient on prevention and future recurrence

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

- Serum calcium and uric acid analysis
- Urinalysis: volume, calcium, oxalates and cystine levels
- Urine pH > 8 suggests urinary tract infection (Mg amm. PO_4)

Urinary tract imaging:

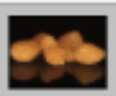
- Ultrasound and i.v. pyelogram

Summary :

Constituents of Kidney Stones

Uric acid stones:
- ~ 8% of renal stones contains uric acid.
- may be associated with hyperuricemia (with or without clinical gout).
-small,friable&yellowish.
- may form staghorn (if big).
- radiolucent (can't be seen be plain X-ray).
- visualized by ultrasonography or I.V. Pyelogram.

Treatment:
- Treatment of cause of hyperuricemia.
-Reduce purine-rich diet .
- Alkalinzation of urine (e.g. by potassium citrate).
- Increase fluid intake .



Cystine stones:
- Rare.
- occurs in cases of homozygous cystinuria (inborn error of amino acid metabolism).
- Soluble in alkaline urine (precipitates by acidic urine).

Treatment:
- Increase fluid intake.
- Alkalinzation of urine .
- Penicillamine.

Stones of calcium salts:
-80% of patients with nephrolithiasis form calcium stone.
- white,hard&radio-opaque.
- Ca-Oxalate:smaller, lodge in ureter.
- Ca-Phosphate: staghorn, in renal pelvis (big).

Causes:
- Hypercalciuria.
- Hyperoxaluria.

Treatment:
-Treatment of primary condition (i.e. infection, hypercalcemia,hyperoxaluria)
- Reducing oxalates in diet.
- Increase fluid intake.
- Acidification of urine.

Mg ammonium phosphate (struvite) stone:
- ~ 10% of all renal stones.
- With chronic urinary tract infection (by urease splitting oraganisms as Proteus species).
- Alkaline urine pH (>7.0).

Treatment:
- Aggressive prevention &treatment of the cause (urinary tract infection).
- Urine acidification.
- Increase fluid intake.
- It may require complete stone removal (percutaneous nephrolithotomy).

MCQs

1-Calcium stones represent :
A) 40% of kidney stones
B) 65%
C) 80%

2-which one of the following is visualized by ultrasonography?
A) Ca stones
B) Uric acid stones
C) Cystine stones

3-Acidification of urine will treat :
A) Uric stones
B) Ca stones
C) Cystine stones
D) a+c

4-Which one of the following is not true about Ca oxalate?
A) Small
B) Found in ureter
C) Staghorn

SAQs

1-What is the other name of Mg ammonium phosphate stone?
…….
2-What is the most imp inhibitor of stone formation?
……

MCQs:

1-c

2-b

3-b

4-c

SAQs:

1) Struvite stone

2) Citrates

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Done by biochemistry team.

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