

KIDNEY STONES

“ THE BEST PREPARATION FOR TOMORROW IS DOING YOUR BEST TODAY”- H. JACKSON BROWN

Color index:

- **Important.**
- **Doctors notes.**
- Extra explanation.

* Please check out [this link](#) to know if there are any changes or additions.

OBJECTIVES:

- list the general physiological and pathological factors that favor kidney stones formation.
- identify the various chemical constituents of kidney stones with reference to the characteristics of each type that help in their clinical diagnosis, and etiological factors that should be considered in medical treatment and prevention of recurrence.

Kidney Stones "Renal calculi"

Introduction:

As the kidneys filter waste from the blood, they create urine. Sometimes, salts and other minerals in urine stick together to form small kidney stones. These range from the size of a sugar crystal to a ping pong ball, but they are rarely noticed unless they cause a blockage. They may cause intense pain if they break loose and push into the ureters, the narrow ducts leading to the bladder.

❖ What are the kidney stones?

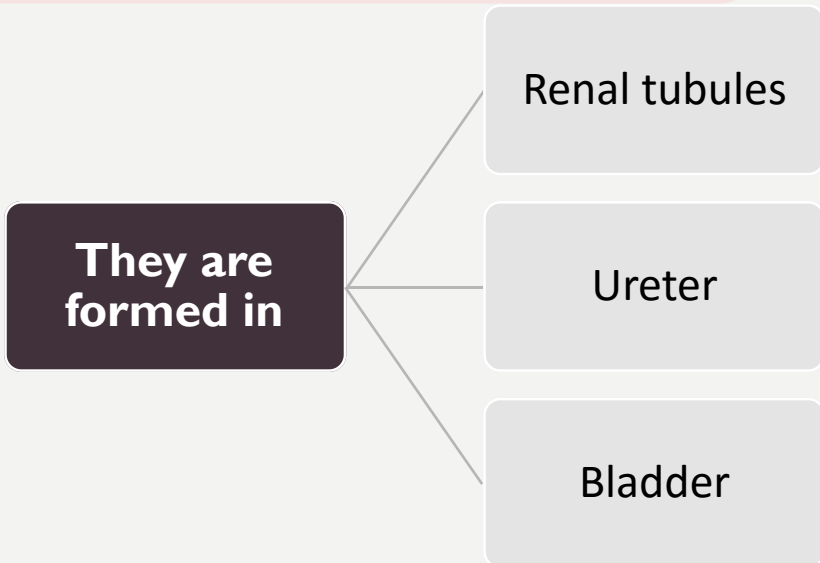
- a hard mass formed in the kidneys, typically consisting of insoluble calcium compounds; a renal calculus.

❖ They're composed of: **metabolic products** present in normal glomerular filtrate.



These products are in **high conc.** (near **or** above maximum solubility)

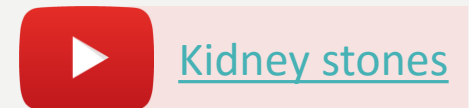
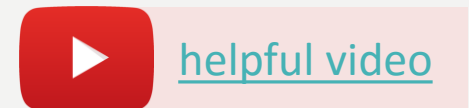
المكسيموم سوليبيلتي ممكن نشبهها بكأس الماء إذا ذوبنا فيه كمية كبيرة من الملح، بحيث الملح راح يذوب حتى يوصل درجة معينة يصير فيها يتراكم ولا يذوب ، لأن الماء تشبع منه.



❖ Kidney Stone Symptoms -for your own knowledge:-

- Severe pain in the back, belly, or groin
- Frequent or painful urination
- Blood in the urine
- Nausea and vomiting

Small stones may pass without causing symptoms.



Conditions causing kidney stone formation

1-High conc. of metabolic products in glomerular filtrate.

Is due to:

Increased excretion of metabolic products forming stones (urinary system is exposed to more and more metabolites):

- High plasma volume (**high filtrate level**).
- Low tubular reabsorption from filtrate.

2-Changes in urine pH.

3-Urinary stagnation (ركود).

4-Lack of normal inhibitors of stone formation in urine.

Low urinary volume (with normal renal function) (urine will be more concentrated):

- **Restricted** fluid intake
- **Increased** fluid loss from the body over a long period of time

Conditions causing kidney stone formation

1-High conc. of metabolic products in glomerular filtrate.

2-Changes in urine pH.

Is due to:

Bacterial infection.

increase precipitation of different salts at different pH:

3-Urinary stagnation (رکود).

A persistently **alkaline** urine (due to upper urinary tract infection) → promotes **Mg Ammonium Phosphate** crystals (Struvite stones).

4-Lack of normal inhibitors of stone formation in urine.

A persistently **acidic** urine → promotes **uric acid** precipitation.

If urine pH changed, some substances will be insoluble, because certain substances are soluble in certain pH

Conditions causing kidney stone formation

1-High conc. of metabolic products in glomerular filtrate.

2-Changes in urine pH.

3-Urinary stagnation (رکود).

4-Lack of normal inhibitors of stone formation in urine.

due to: **Obstruction of urinary flow**

Urine contains substances that inhibit the nucleation, growth, aggregation, and cell attachment of crystals. These may function to protect the kidney against the possibility of pathological calcification in tubular fluid and urine, which are generally supersaturated with respect to calcium salts, thereby preventing stone formation.

Inhibitors of stone formation:

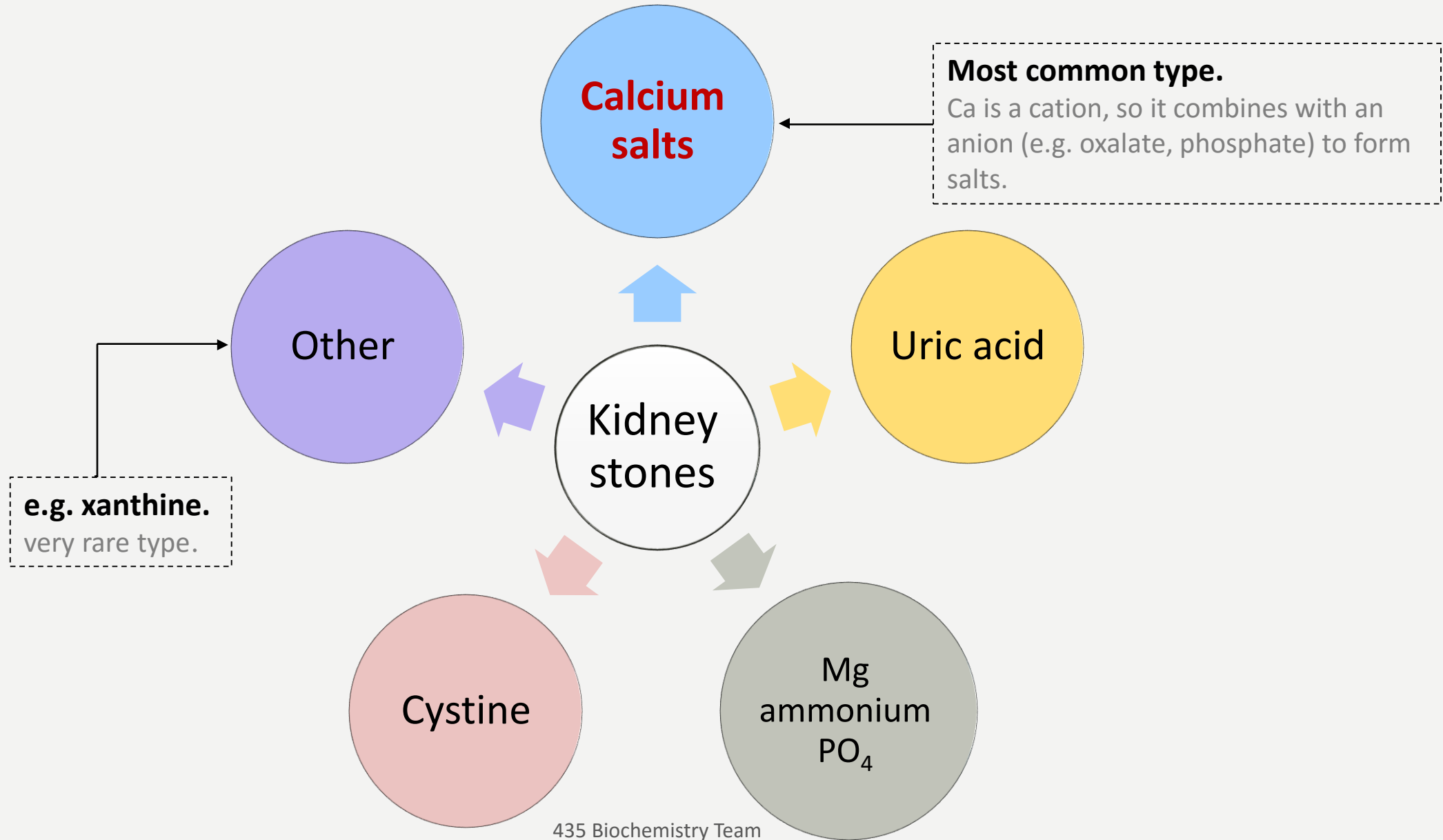
❖ **e.g.:**

- **Citrates**
- Pyrophosphate
- Glycoproteins

❖ **Function:** Inhibit the growth of Ca⁺⁺ salts crystals“ calcium phosphate and calcium oxalate crystals”.

- In type I renal tubular acidosis, hypocitraturia (low citrate levels the urin) → **renal stones**

Constituents of kidney stones



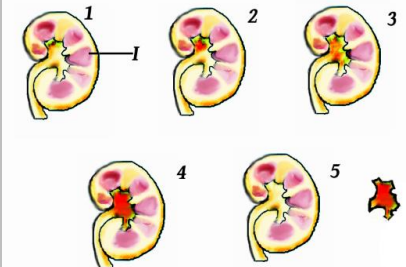
Calcium salt stones

- ❖ **80% of kidney stones** “nephrolithiasis” **contain calcium** (the most common type of kidney stone).
- ❖ **General appearance:** White, hard, **radio-opaque** (appears as a white shadow in the x-ray).
- ❖ **Occurs in two major forms:** calcium oxalate and calcium phosphate.

calcium oxalate	calcium phosphate
present in <u>ureter</u>	<u>staghorn</u> in renal pelvis (looks like the horn of the stag (the male deer)).
small	large
More common	Less common
may be caused by high calcium and high oxalate excretion	caused by the combination of high urine calcium and alkaline urine, meaning the urine has a high pH.

- ❖ **So The type of salt depends on:**
 - Urine pH.
 - Availability of oxalate.

Staghorn **calculi**



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.**

Hypercalciuria can occur due to increased bone resorption without Hypercalcemia.

Primary hyperoxaluria

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

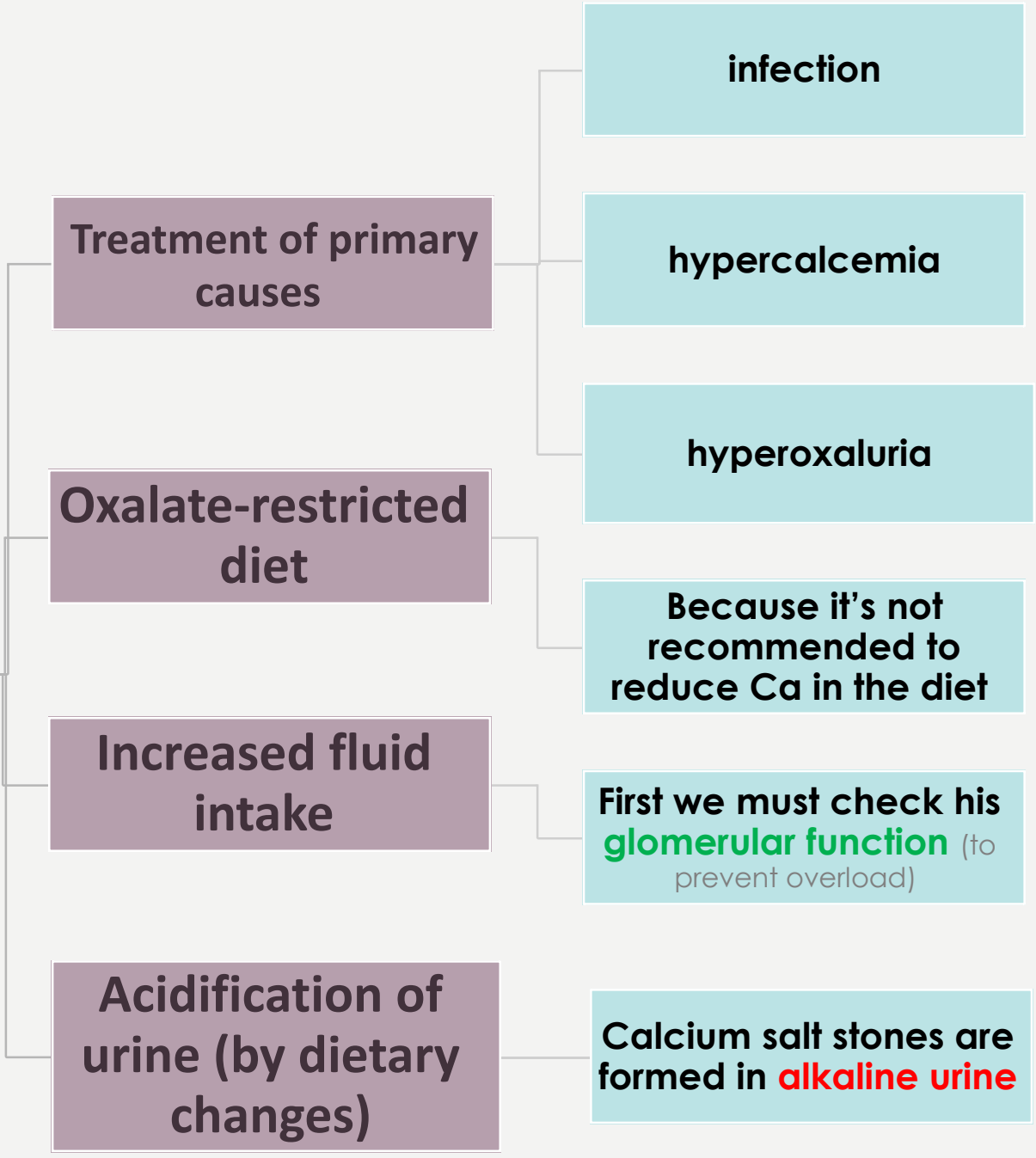
This disease causes inability to metabolize oxalate, increasing its concentration in the serum.

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.

Dr.Reem sallam said that we don't have to memorize the numbers, reference range will be given in the exam

Treatment of Calcium salt stones (conservative line treatment)

Ca precipitates in alkaline environment, so we make the urine acidic to inhibit the formation of stones (Ca dissolves in the acidic environment)



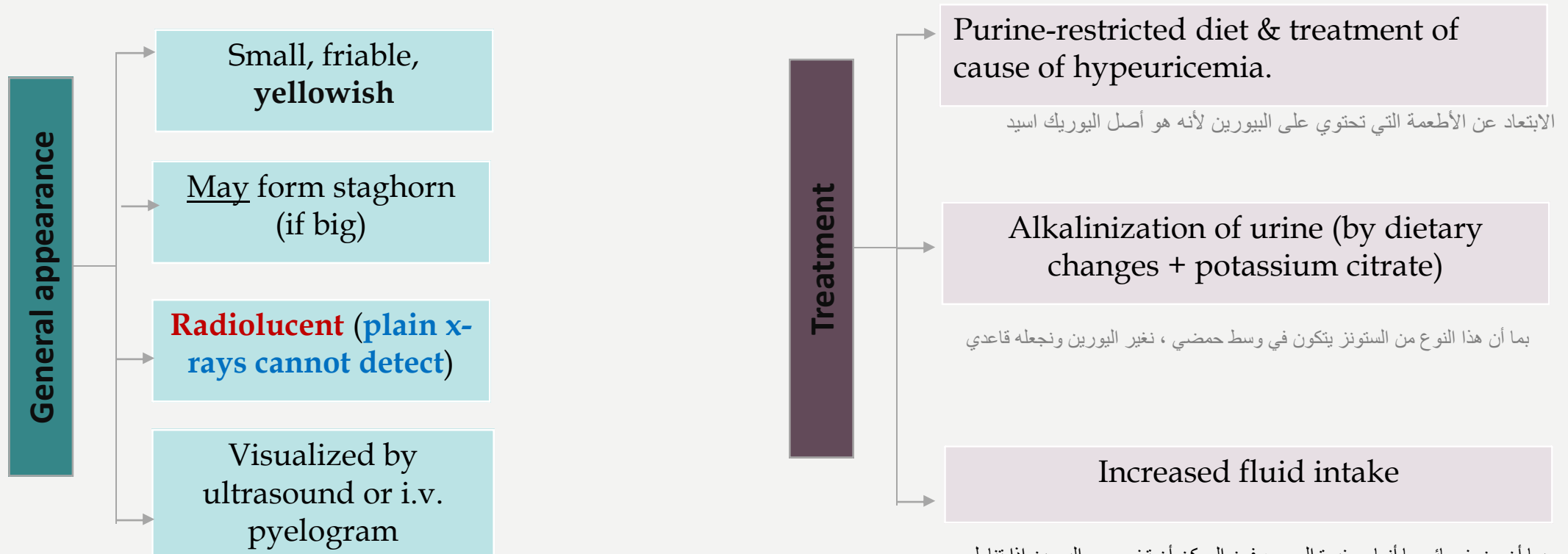
URIC ACID STONES

- ❖ Recall: what is uric acid? it is a chemical created when the body breaks down purines.
- ❖ About 8% of renal stones contain uric acid.
- ❖ Form in **acidic urine** (عكس الكالسيوم ستونز التي تتكون في وسط قاعدي)



(Several products of purine metabolism are relatively insoluble and can precipitate when urinary pH is low)

May be associated with hyperuricemia (**with or without clinical gout**)



الابتعاد عن الأطعمة التي تحتوي على البيورين لأنه هو أصل اليوريك اسيد

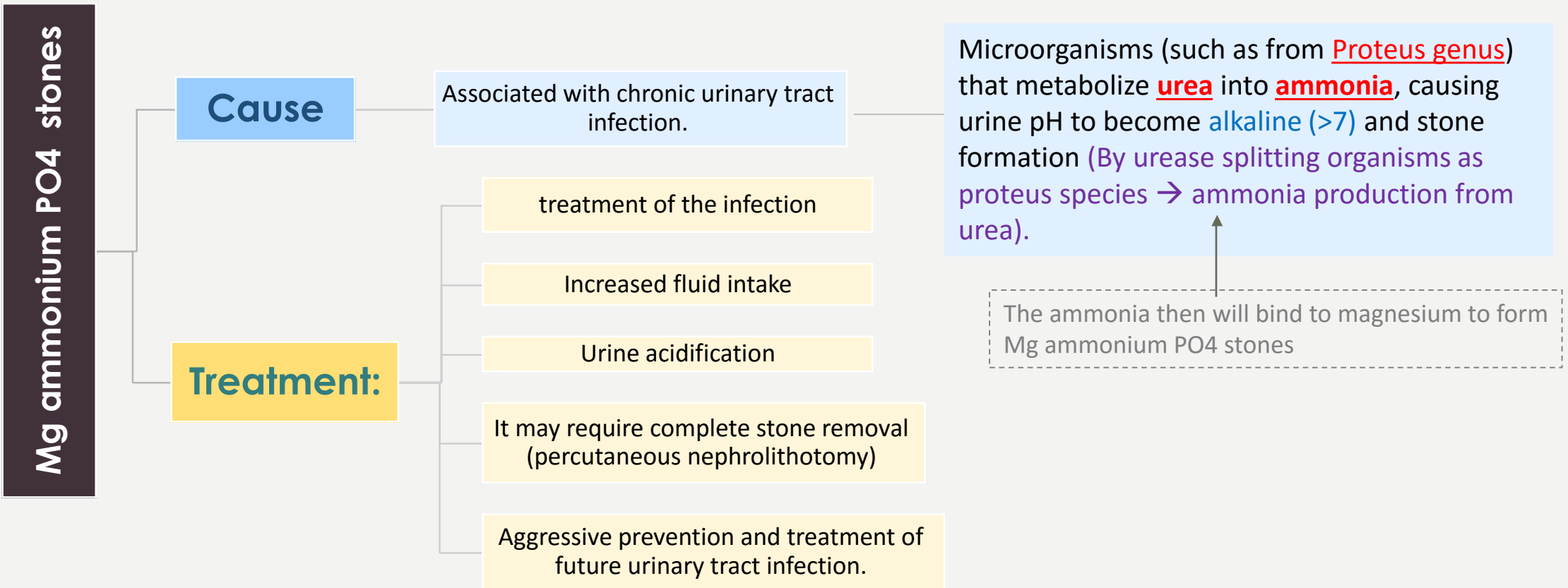
بما أن هذا النوع من الستونز يتكون في وسط حمضي ، نغير البيورين ونجعله قاعدي

بما أن من خصائصها أنها صغيرة الحجم ، فمن الممكن أن تخرج مع اليورين إذا تناول الشخص مشروبات كثيرة

Mg ammonium PO4 stones (struvite kidney stones)

- ❖ About **10%** of all renal stones contain **Mg amm. PO4**.
- ❖ It is also called **struvite kidney stones**.
- ❖ **Commonly associated with:** **staghorn** calculi (75% of staghorn stones are of **struvite** type).

- **Extra:** Mg ammonium PO4 is kind of mineral that naturally found in the earth. Its geological name is “struvite”



Cystine stones – Extra-:

❖ What is Cystine?

it is a type of amino acids formed from the oxidation of two cysteine molecules (a dimer of two cysteine).

It forms 10-14% of human's hair & skin.

It's common in many foods such as meat, eggs, and whole grains.

What is Cystinuria?

It is an inherited autosomal recessive disease that is characterized by formation of cystine stones in the kidneys, ureter, and bladder.

The defect in the gene (which is responsible of the reabsorption of proteins in the proximal tubules) prevent proper reabsorption of +ve charged amino acids (e.g. cystine). Thus, its concentration in urine increases. And eventually the cystine crystals will form and cause kidney stones.

Cystine stones

❖ What is it?

It is a **rare** type of kidney stone.

❖ Why does it happen?

Due to **homozygous cystinuria** (inborn error of amino acid metabolism).

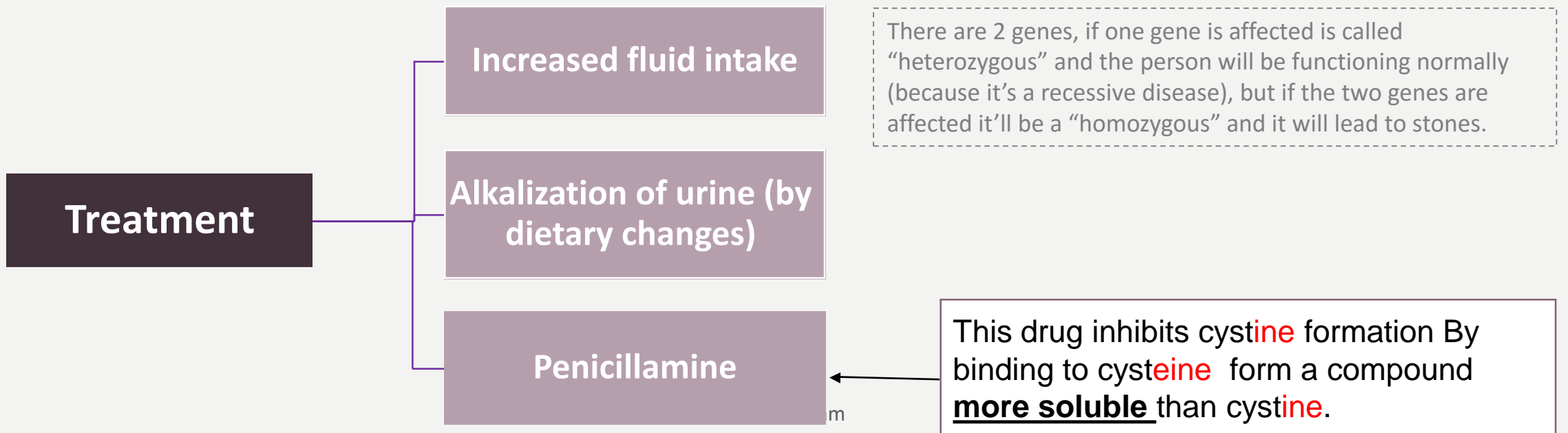
Could be of a genetic disease (genetic deficiency of the enzyme that metabolize the cystine).

❖ forms in :

Acidic urine (it's soluble in **alkaline urine**).

❖ It's characterized by :

Faint radio-opaque. (like dark spots)



Laboratory investigations of kidney stones

If stone has formed and
removed (available)

If stone has not formed
(not available)

- ❖ **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

If stone has formed and removed (available)

If stone has not formed (not available)

Serum calcium, uric acid analysis and PTH.

Blood analysis

➤ volume, calcium, oxalates and cystine levels.

(Finding one of these substances elevated in urine, doesn't necessarily mean that the patient has stones, he may be in risk of stone forming)

Urinalysis

If the PH > 8 suggests urinary tract infection (Mg amm. PO₄).

Urine pH

Ultrasound, CT scan and i.v. pyelogram. (to check out if there's a stone or not)

Urinary tract imaging:

qualitative (if +ve: 24 hours urine)

Screening of urine for cysteine

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

TO SUMMARIZE: EVALUATION AND SUBSEQUENT TREATMENT:

- ❖ Retrieve stones and send for analysis.
- ❖ Subsequent therapy depends on stone & biochemical abnormalities.
- ❖ ***ALL patients should increase fluid*** intake to > 2L/day
- ❖ Do a complete evaluation in certain patients (**those with moderate-high risk**):
 - **Middle-aged, White, Males**, with **+ ve Family History**
 - Patients with **chronic diarrheal states** and/or **malabsorption**, **pathological fractures**, **osteoporosis**, **UTIs**, or **gout**.
 - **Patients with certain types of stones:**
 - e.g. stones composed of calcium phosphate (hard stone) or struvite (@ risk for staghorn calculi).

1. Most common type of stone is :

- A. Calcium
- B. Mg ammonium PO₄
- C. Uric acid
- D. cysteine

2. Patient with Hyperoxaluria Was found to have stones. What is the most probable constituent of these stones ?

- A. Calcium phosphate
- B. Uric acid
- C. Cysteine
- D. Calcium Oxalate

3. Calcium stones are treated by

- A. Alkalization of urine
- B. Acidification of urine
- C. Penicillamine
- D. None

4. Uric acid stones are visualized by

- A. X-ray
- B. IV-Pyelogram
- C. ultrasound
- D. B and C

5. Infections are associated with what type of stone

- A. Calcium
- B. Mg ammonium PO₄
- C. Uric acid
- D. cysteine

6. Patient with stone reported to be Staghorn shaped. Most probable type is ?

- A. Calcium phosphate
- B. Uric acid
- C. Mg ammonium PO₄
- D. Calcium Oxalate

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

7. Penicillamine is used to treat :

- A. Calcium
- B. Mg ammonium PO₄
- C. Uric acid
- D. cysteine

8. Patient with Uric acid stone should not be consuming :

- A. Purines
- B. Oxalates
- C. Phosphates
- D. Magnesium

9. Patient with Urinary PH of 9.2 is at risk of developing which stone :

- A. Calcium
- B. Mg ammonium PO₄
- C. Uric acid
- D. cysteine

❖ Case1: A 44 year old woman comes to the clinic complaining from bone and joint pain, Fragile bones that easily fracture. upon investigation ,the doctors discovered the presence of kidney stones. After further testing she was diagnosed with primary hyperparathyroidism due to sudden enlargement of parathyroid glands.

What is the type of stones formed in this case? Explain your answer.

-stones of calcium salts.

- 1-Because enlarged parathyroid glands lead to primary hyperparathyroidism
- 2-hyperparathyroidism leads to increased release of calcium from bone to the blood (that is why patient presented with easily fractured bones)
- 3-(hypercalcemia) contributes to formation of stones of calcium salts.

❖ Case 2: A 5th year medical student drinks an abundant amount of coffee and tea everyday to keep up with his studies. He neglects to drink a sufficient amount of water. He came to the ER with pain during urination and was later diagnosed with nephrolithiasis.

- **What is the cause of this case of nephrolithiasis?**

-Restricted fluid intake with intake of diuretics(tea and coffee) which leads to dehydration, hence stone formation.

- **Where do you expect to see these calculi? (Anatomy question)**

- At ureteropelvic junction.
- At pelvic inlet (site of crossing of common iliac artery).
- At site of entrance to bladder.

❖ Case 3: A 55 year old male was diagnosed with gout a year ago. He came recently to the ER complaining from blood in his urine and pain. After ultrasound they found stones in the urinary tract.

- **What is the type of stones seen?**

uric acid stones

- **Give an alternative way to visualize uric acid stones.**

IV pyelogram.

- **What are the characteristics of this stone?**

1-small friable and yellowish (may form staghorn if big)

2-radiolucent

❖ **Case 4:** A 25 year old female came to the clinic complaining from constant muscle weakness, confusion and decreased urine output . Nephrolithiasis was later discovered by ultrasound. After further investigation, she was diagnosed with type 1 renal tubular acidosis.

- what is the most common type of stone formed in this case of nephrolithiasis? Explain your answer.

-stones of calcium salts.

Because distal tubular acidosis is known to cause a decrease in citrate in urine(which inhibits growth of calcium crystals),Hence this decrease promotes the formation of stones of calcium salts.

-Where do you think these stones will most likely lodge?

If Ca-Oxalate: smaller, lodge in ureter.

If Ca-Phosphate: staghorn, in renal pelvis.

- note: weakness ,confusion are signs of type one renal tubular acidosis.

❖ **Case 5:** 15 year old male comes to the ER, with pain during urination. The doctors learned from patient's history that he suffers from fat malabsorption. After further investigation he was diagnosed with nephrolithiasis.

What is the type of stone?

Calcium oxalate

Where is it found?

Ureter

What is the course of treatment?

1-Fluid intake increase

2-Acidification of urine(because calcium stones precipitate and favor alkaline PH ,hence we must acidify urine to excrete and solubilize it)

3-Reduction of oxalate intake(such as spinaches or almonds)

4-Treatment of underlying cause(hyperoxaluria in this case)

Way to memorize:FART is used for treatment of calcium salts.

SAQs

❖ **Case 6:** A 25 year old sexually active female came to the ER with complaining from bloody urine and severe pain during urination. A urine dipstick test showed the presence of nitrites. The doctors later diagnosed with lower UTI, Upon further investigation there's also the lodging of kidney stones.

- **What is the most likely organism to cause nephrolithiasis? And why?**

Proteus due to urease enzyme which forms ammonia, leading to stone formation.

- **What is the type of stone formed in this case.**

Magnesium ammonium phosphate stones.

- **How can you alter the patients urine to facilitate excretion of stone.**

Acidification of urine is required for excretion and solubilization of stone.

- **If magnesium ammonium phosphate is causing severe obstruction and is resistant to treatment, what is the next step in the treatment plan?**

We must perform percutaneous nephrolithotomy.

Team Members:

Team Leaders:

- شهد العنزي.
- عبدالله الغزي.

- خالد النعيم .
- ثاني معافا .
- فارس المطيري .
- زياد العنزي .
- محمد الصهيل .
- إبراهيم الشايح .
- عبدالله الشنيفي .
- أحمد الرويلي .
- فراس المؤمن .

- نوره الرميح .
- بدور جليدان .
- علا النهير .
- رغد المنصور .
- دلال الحزيمي .
- أفنان المالكي .
- خوله العريني .
- ريفان هاشم .
- غاده القصيمي .
- منيره الحسيني .
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