[lecture 3]

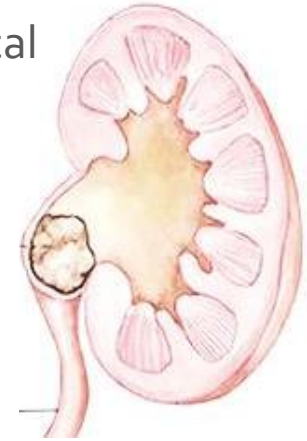
Kidney Stones

Biochemistry Team

Teams

Objectives

- **Upon completion of this lecture, the students should be able to:**
  - Recall general physiological and pathological factors that favor kidney stones formation.
  - Identify the chemical constituents and characteristics of kidney stones that help in identifying the causes, diagnosis, treatment and prevention of kidney stones.



(اخر سلايد،، اسئلة جميله ومهمهـ ترتب افكارك،)

Female Notes | Red = Import -ant | Blue = explain | Green = addition notes

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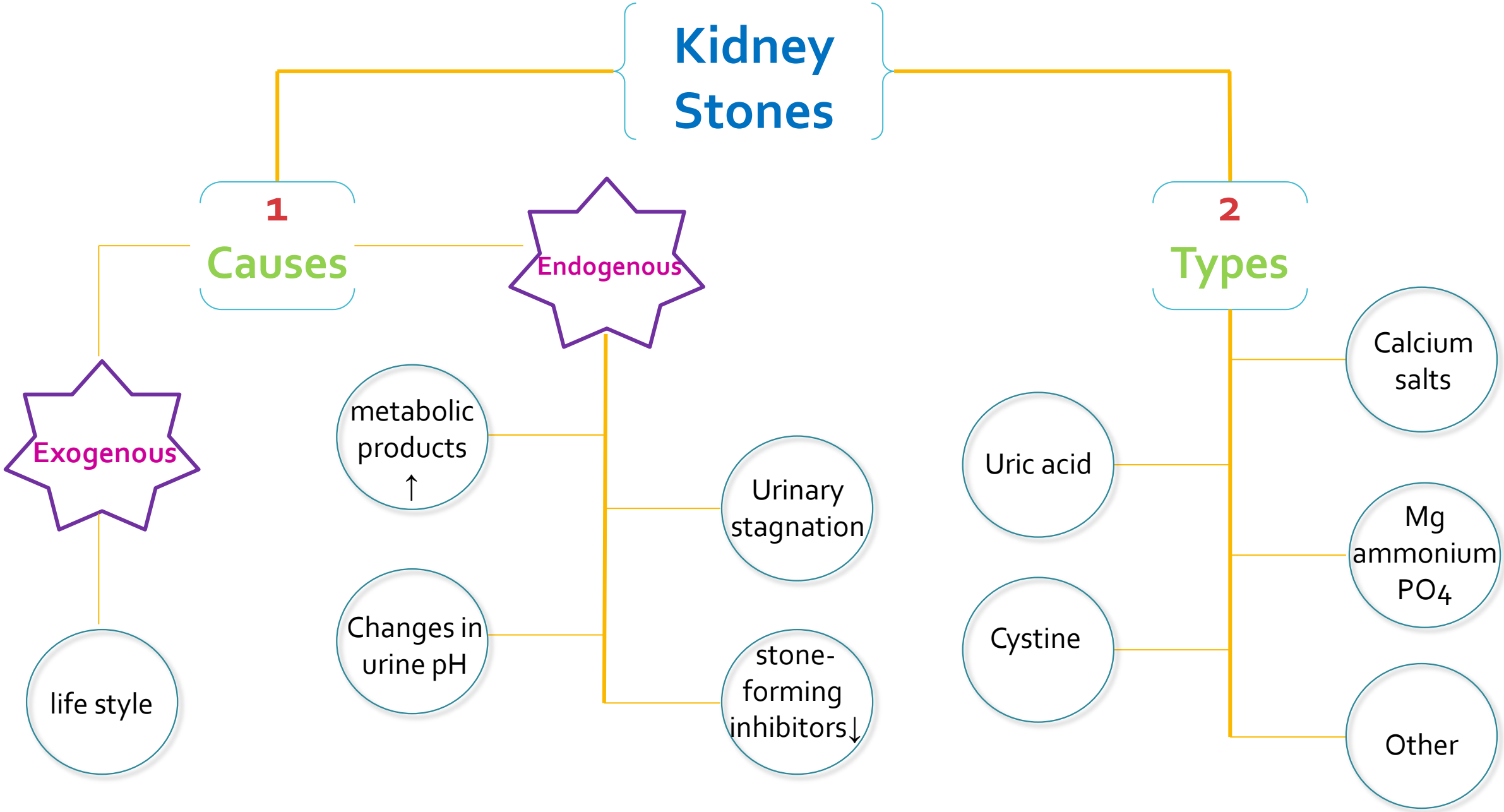

Kidney Stones
1
Causes
Exogenous
life style
Endogenous
metabolic products ↑
Changes in urine pH
Urinary stagnation
stone-forming inhibitors↓
2
Types
Uric acid
Cystine
Calcium salts
Mg ammonium PO4
Other

What are kidney stones (nephrolithiasis) ?

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

Conditions causing kidney stone formation :

Exogenous
sometimes life style

Endogenous

Endogenous Conditions causing kidney stone formation :

High conc. of metabolic products in glomerular filtrate

due to:

- Low urinary volume (with normal renal function) due to restricted fluid intake.
- Increased fluid loss from the body.(sweating, diarrhea) Over a long period of time.
- Increased excretion of metabolic products forming stones.
- High plasma volume (high filtrate level)
- Low tubular reabsorption from filtrate

Changes in urine pH

due to:

- Bacterial infection
- Precipitation of salts at different pH

Remember : PH Can cause a change in solubility

- A persistently **acidic** urine → promotes uric acid precipitation
- A persistently alkaline urine (due to upper urinary tract infection)→ promotes Mg Ammonium Phosphate crystals (Struvite stones)

Deficiency of stone-forming inhibitors in urine

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

They inhibit the growth of Ca^{++} salts crystals

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

Urinary stagnation ركود

due to:

- Obstruction of urinary flow → In case of enlarge prostate .

Types of kidney stones :

1. Calcium salts
2. Uric acid
3. Mg ammonium PO_4
4. Cystine

- Other (xanthine, etc.)

*Will discuss one by one

Very common

1-Calcium salt stones

80% of kidney stones contain calcium , formed in Alkaline Urine

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

General appearance

- White, hard, radio-opaque
- Calcium PO_4: **staghorn in renal pelvis (large)**
- Calcium oxalate: **present in ureter (small)**

Mostly: calcium oxalate

Causes of calcium salt stones

❖ **Hypercalciuria**:

Could be due to ↑ PTH

- Increased urinary calcium excretion
- Men: > 7.5 mmols/day
- Women > 6.2 mmols/day
- May or may not be due to hypercalcemia

due to hypercalcemia (most often due to 1ary hyperparathyroism)
sometimes, Ca^{++} salts stones are found with no hypercalcemia

❖ **Hyperoxaluria**:

- Causes the formation of calcium oxalates without hypercalciuria
- Diet rich in oxalates
- exogenous (Diet rich in oxalates)
- Increased oxalate absorption in fat malabsorption

Normally, Oxalate and calcium bind together in the intestine and leave the body together in the stool When large amounts of unabsorbed fat are available, calcium preferentially binds to fat instead of oxalate. This leaves oxalate available to be easily reabsorbed by the colon and ends up in the urinary tract.

❖ **Primary hyperoxaluria**: Due to inborn errors , Urinary oxalate excretion: > 400 mmols/day

^*

Calcium oxalate stones

Treatment

- Treatment of primary causes such as infection, hypercalcemia, hyperoxaluria
- Oxalate-restricted diet (it is not recommended to reduce calcium in diet)
- Increased fluid intake (if no glomerular failure)
- Acidification of urine (by dietary changes) (as ppt. is favoured by alkaline conditions)

Why we shouldn't reduce calcium in diet ?

. If there is not enough calcium, then the extra oxalate will have nothing in the intestine to bind to, so it will be absorbed into the bloodstream and end up in the urine, where it will form a calcium oxalate stone.

2-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 (if big)
- Radiolucent (plain x-rays cannot detect)
- Visualized by ultrasound or i.v. pyelogram

Treatment

- Treatment of cause of hyperuricemia
- Purine-restricted diet
- Alkalinization of urine (by dietary changes)
  (e.g. by potassium citrate)
- Increased fluid intake

3-Mg ammonium PO_4 stones

- Commonly associated with staghorn calculi
- 75% of staghorn stones are of **struvite type**

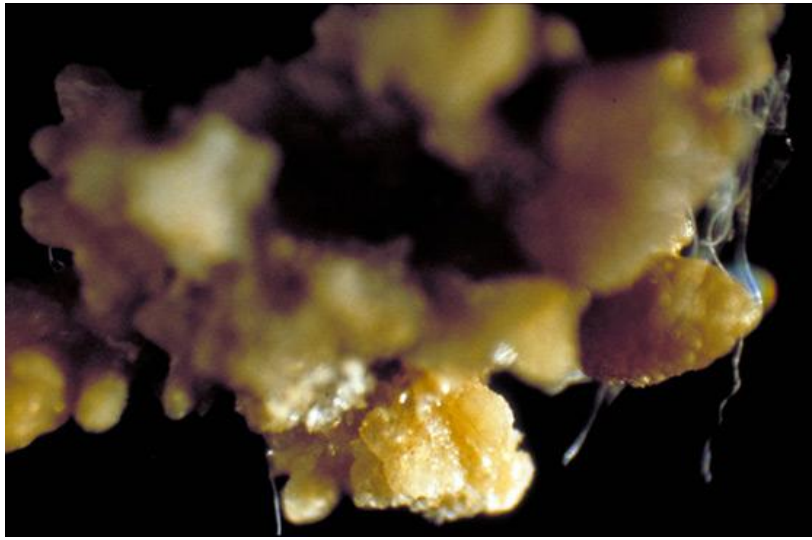
- About 10% of all renal stones contain Mg amm. PO_4
- Also **called struvite kidney stones**
- **Associated with chronic urinary tract infection.**
  - Microorganisms (such as from Proteus genus) that metabolize urea into ammonia (by an enzyme called urease)
  - **Causing urine pH to become alkaline and stone formation**

Treatment

- Aggressive prevention & Treatment of infection (urinary tract infection)
- Acidification of urine .
- Increased fluid intake.
- It may require complete stone removal (percutaneous nephrolithotomy)
- Aggressive prevention & treatment of future urinary tract infection

4-Cystine stones

- A rare type of kidney stone
- Due to homozygous cystinuria (genetic)
- (inborn error of amino acid metabolism)
- 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)

Cystine is composed of **two cysteines** linked by a **disulfide** bond. Penicillamine breaks the bond and binds to cysteine to form a compound more soluble than cystine , Thus inhibit the synthesis of cystine .

Laboratory investigations of kidney stones

If stone has formed and removed:
(with urine or by surgical intervention)

- Chemical analysis of stone helps to:

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

If stone has not formed:

- This type of investigation identifies causes that may

➢ contribute to stone formation
➢ Serum, calcium, uric acid , and [PTH] analysis
➢ Urinalysis: volume, calcium, oxalates and cystine levels
➢ Urine pH > 8 suggests urinary tract infection (Mg amm. PO_4)
➢ **Screening of urine for cystine:** qualitative (if +ve: *24 hours urine*)

- Urinary tract imaging:

➢ CT, Ultrasound and i.v. pyelogram

QUESTIONS

1. Which of the following formed in alkaline urine:-
a) Calcium salt stones
b) Cystine stones
c) Mg ammonium PO_4 stones
d) A , C

2. Which of the following formed in acidic urine:-
a) Calcium salt stones
b) Cystine stones
c) Uric acid stones
d) B , C

3. Calcium oxalate is present in:-
a) Renal pelvis
b) Renal sinus
c) Ureter
d) Urinary bladder

4. Which of the following is treated by alkaline urine:-
a) Calcium salt stones
b) Cystine stones
c) Mg ammonium PO_4 stones
d) A, C

5. The renal calculi seen in patients with chronic urinary tract infection are most likely to be:
a) Struvite
b) Uric acid
c) Calcium phosphate
d) Calcium oxalate

6. A 40-year-old patient has a radiopaque staghorn this stone can NOT be:
a) Cystine
b) Struvite
c) Uric acid
d) Calcium oxalate

Answers

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

Biochemistry
Team

If you find any mistake, please contact us:)

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