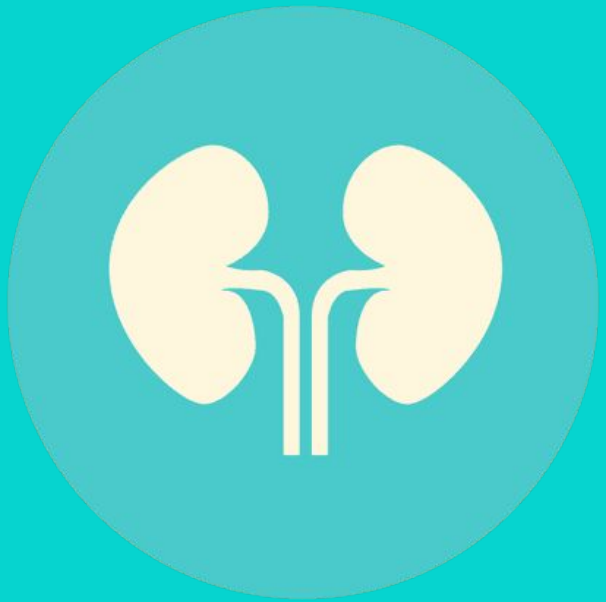
Kidney stones



Editing file

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

Overview:

- Introduction
- Conditions causing kidney stone formation
- Types of kidney stones
  - Calcium salts
  - Uric acid
  - Mg ammonium PO4
  - Cystine
  - Other (xanthine, etc.)
- Laboratory investigations

Color Index:

- Important
- Dr's notes

kidney stones

"Renal calculi"

- Location of Formation: 1) renal tubules 2) ureter 3) bladder.
- Composition: metabolic products present in **glomerular filtrate.**
- ☆ Concentration of the products forming kidney stones: near or above maximum solubility (high) [1]

Types of kidney stones

- Calcium salts
- Uric acid
- Mg ammonium PO_4
- Cystine
- Other (xanthine, ..etc)

Conditions causing kidney stone formation	Due to
↑ conc. Of metabolic products in glomerular filtrate	**Increase in:** - Fluid loss from the body. - Excretion of metabolic products forming stones. - Plasma volume (high filtrate level).[2] **Decrease in:** - Urinary volume (with normal renal function) due to restricted fluid intake. - Tubular reabsorption from filtrate
Changes in pH	**Urine PH** Normal range [5.5 - 6.5] ↑ **Alkaline** — Due to: **Precipitation** and Upper urinary tract **infection** [3] Promotes: Mg Ammonium Phosphate crystals (Struvite stones). ↓ **Acidic** — Promotes: Uric acid precipitation.
Urinary stagnation	- **Obstruction of urinary flow.**
Deficiency of stone-forming inhibitors	- **Hypocitraturia "In type I renal tubular acidosis"** [4] ☆ **Inhibitors of calcium phosphate and calcium oxalate crystals:** • Citrate • Pyrophosphate • Glycoproteins

Extra info :

1. **maximum solubility is the maximum amount of solute the solvent can solubilize,**

for example if we keep adding salt (sodium) to a glass of water The water will reach a limit at which it cannot accept any more salt and it precipitate at the bottom of the glass.

Therefore if conc. is **above** maximum solubility, it will precipitate **directly**.

But if it was **near** maximum solubility, any stagnation or change in pH will make it precipitate.

2. **Recall from physiology:** Increased GFR will cause the urine to pass in a high volume (high velocity) and therefore it's reabsorption will decrease

3. bacteria release an Enzyme **urease enzyme** which converts **urea** to **Ammonia** and **alkalizes** the urine.

4. **type I renal tubular acidosis** may be caused either by failure to reabsorb bicarbonate

or by insufficient secretion of hydrogen ions

Calcium salt stones

☆ **80%** of kidney stones.

☆ **The type of salt depends on:**

1. Urine pH
2. Availability of oxalate[1]

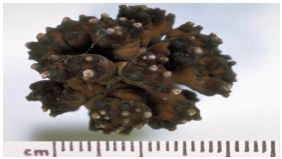
General appearance

- **White, hard, radio-opaque** [2]

Types

1) **Calcium oxalate (mostly)**
   - Location: ureter
   - Size: small

2) **Calcium Po_4 (less often)**
   - Location: renal pelvis
   - Size: large
   - Shape : staghorn (Branched)



Causes

Hypercalciuria

1) **Increased urinary calcium excretion :**
   - ☆ Men > 7.5 mmols/day
   - ☆ Women > 6.2 mmols/day

2) **hypercalcemia :**
most often due to 1^{ary} hyperparathyroidism.
   - ☆ sometimes with no hypercalcemia.

Hyperoxaluria

☆ **Formation of calcium oxalates without hypercalciuria** [3]

1) **Diet :** rich in oxalates.[4]
2) **Fat Malabsorption :** ↑ oxalate absorption [5]
3) **Primary hyperoxaluria :** Inborn errors [6]
   - ☆ Urinary oxalate excretion > 400 µmol/24 Hours.

Treatment

- **Treatment of primary causes :** • infection • hypercalcemia • hyperoxaluria
- **Oxalate-restricted diet**
- **↑ fluid intake** "if no glomerular failure" [7]
- **Acidification of urine** "by dietary changes" [8] ☆ Calcium salt stones are formed in alkaline urine

Extra info :

1. If there is **too much** of **oxalate** present it will lead to **Ca-Oxalate** stones **Otherwise** we will have **Ca-Phosphate.**

2. **Radio-opaque:** can be seen with normal X-ray.

3. because oxalate has a **high binding capacity** with the calcium which makes the Ca-oxalate stones

4. E.g. tomatoes spinach and figs.

5. in the colon oxalate normally Binds with calcium and get excreted malabsorption of dietary fat causes increase of fat in the colon As we know **fat attracts calcium** And therefore it'll bind with it so, oxalate won't bind with the calcium and gets reabsorbed.

6. **enzymes deficiencies** which lead to excess Production of oxalate in the body

7. **to get rid of the Stones**

8. **If dietary changes failed we use drugs**

Uric Acid Stones

☆ About **8%** of renal stones

☆ Form in **acidic** urine [1]

General appearance

- Small, friable [2] , yellowish
- May form staghorn (if big)
- Radiolucent (plain x-rays cannot detect)
- Visualized by ultrasound or i.v. pyelogram [3]

Causes

May be associated with hyperuricemia
(with or without gout)

Treatment

- Treatment of cause of hyperuricemia.
- Purine-restricted diet
- ↑ fluid intake
- Alkalinization of urine "by dietary changes" [4]

Extra info :

1. meat consumption makes the urine more acidic while fruit consumption alkalizes the urine
2. breaks easily
3. Intravenous pyelogram. A series of x-ray images are taken at different times. This is to see how the kidneys remove the dye and how it collects in the urine.
4. In severe cases we use I.V infusion of Bicarbonate

Mg ammonium PO_4 stones

☆ About 10% of renal stones

☆ Also called struvite kidney stones

General appearance

Causes

☆ **Chronic urinary tract infection**

- **Microorganisms**: e.g. **Proteus genus**

" Metabolize urea into ammonia ⟶ urine pH to become **alkaline** "

Complications

☆ **Commonly associated with staghorn calculi** [1]

- 75% of staghorn stones are of struvite type

Treatment

- **Treatment of infection**
- **↑ fluid intake**
- **Urine acidification**
- **complete stone removal** "percutaneous nephrolithotomy" [2] ☆ In some cases

Extra info :

1. **Staghorn calculi:**
branching structures that develop due to progressive accretion of salts

2. **percutaneous nephrolithotomy**

Q1: A patient has staghorn stones with no UTI, what is the most likely type of stone?
Answer: Calcium phosphate

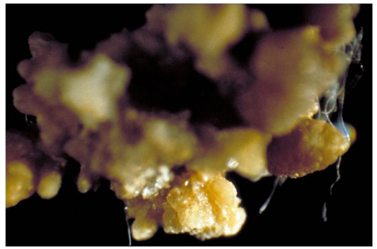
Q2: A patient has a staghorn shaped stone and a UTI, what is the most likely type of stone?
Answer: Struvite stone

Cystine stones

☆ A rare type of kidney stone ☆ Form in **acidic** urine ☆ Soluble in alkaline urine

General appearance

- **Faint radio-opaque**



Causes

☆ **homozygous cystinuria** [1]

Treatment

- ↑ **fluid intake**
- **Alkalinization of urine** "by dietary changes"
- **Penicillamine** ☆ MOA: binds to **cysteine** to form a compound more soluble than cystine

Extra info :

☆ **Cystine** is a dipeptide of the amino acid **cysteine**

☆ the dipeptide (**Cystine**) is less soluble. Than the amino acid (**cysteine**)

1. an autosomal-recessive defect in reabsorptive transport of cystine

2. **Eating Vegetables:**
→ Alkalization of urine
→ For acidic stones

Eating Meat:
→ Acidification of urine
→ For Alkaline stones

Lab investigations for kidney stones

Stone has formed and removed

☆ **Chemical analysis of stone :**

- Identify the cause [1]
- Advise patient on prevention and future recurrence

Stone has not formed

☆ **identify causes that may contribute to stone formation :**

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

☆ **Urinary tract imaging :**

- CT
- Ultrasound
- i.v. pyelogram

Extra info :

1. By conforming the shape → type of stone → the cause

Quiz

MCQs :

Q1: Which of the following cause high conc.of metabolic products in glomerular filtrate?
a) High urinary volume **b)** High plasma volume
c) decreased excretion of metabolic products **d)** High tubular reabsorption from filtrate.

Q2: Which of the following can cause struvite stones formation:
a) pH below 5.5 **b)** pH above 8 **c)** Upper urinary tract infection **d)** Both B and C

Q3: Which one of the following stones are also called struvite kidney stone?
a) Uric acid stones **b)** Cystine stone **c)** Mg ammonium PO4 stones **d)** Calcium salt stones

Q4: Uric acid stones maybe associated with:
a) Hyperuricemia **b)** Hypercalcemia **c)** Hyperkalemia **d)** Hypouricemia

Q5: Which medication is used to treat cystine stones?
a) Penicillin **b)** Penicillamine **c)** Allopurinol **d)** Aspirin

Q6: Urinalysis is used to measure all of the following except:
a) Calcium levels **b)** Oxalates levels **c)** Cystine levels **d)** Sodium levels

Q7: Infections are associated with what type of stone?
a) Calcium **b)** Mg ammonium PO_4 **c)** Uric acid **d)** Cysteine

Q8: Patient with stone reported to be Staghorn shaped, what is the most probable type?
a) Calcium phosphate **b)** Uric acid **c)** Mg ammonium PO_4 **d)** Calcium Oxalate

SAQs :

Q1: What is the most common type of kidney stone?

Q2: List THREE conditions that can cause kidney stones formation

Q3: Describe the general appearance of uric acid stones.

Q4: What is the mechanism of penicillamine?

Q5: What's the concentration of the product forming kidney stones?

★ MCQs Answer key:

1) B 2) D 3) C 4) A 5) B 6) D 7) B 8) C

★ SAQs Answer key:

1) Calcium

2) ↑ conc.Of metabolic products in glomerular filtrate Change in urine pH, Urinary stagnation, Deficiency of stone-forming inhibitors in urine.

3) Small, friable , yellowish , May form staghorn (if big), Radiolucent , Visualized by ultrasound or i.v. pyelogram

4) Binds to cysteine to form a compound more soluble than cystine

5) Near or above maximum solubility

☆ Team members :

Girls team:

- ★ Ajeed Al-rashoud
- Alwateen Albalawi
- Abeer Alkhodair
- Elaf Almusahel
- Haifa Alessa
- Lama Alassiri
- ★ Lina Alosaimi
- Nouf Alhumaidhi
- Noura Alturki
- ★ Nouran Arnous
- Reem Algarni
- Rema Alkahtani
- Shahd Alsalamh
- ★ Taif Alotaibi

Boys team:

- Alkassem Binobaid
- Fahad Alsultan
- Fares Aldokhayel
- Naif Alsolais
- Sultan Alhammad

☆ Team leaders :

Deema Almaziad

Mohannad Alqarni

☆ إن الله يعطي أصعب المعارك لأقوى الجنود ، تذكر دوماً ما تفعلهُ اليوم هو غداً

438 BIOCHEMISTRY TEAM

We hear you