Biochemistry Teamwork
Kidney Stones

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What are kidney stones?

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:

Conditions can be:-

- Exogenous :- ⇒ Sometimes life style
- Endogenous:-

High conc. of metabolic products in glomerular filtrate
Changes in urine PH >> (**Solubility depends on the degree of PH**)
Increasing the pH = decreasing the solubility
Urinary stagnation
Deficiency of stone-forming inhibitors in urine

1) 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 { e.g. ;- Sweating, Diarrhea }
- Increased excretion of metabolic products forming stones
- High plasma volume (high filtrate level)
- Low tubular reabsorption from filtrate

2) Changes in urine pH

Due to:

Bacterial infection<< very Important
Precipitation of salts at different pH

REMEMBER
!!PH can cause a changein solubility

3) Urinary stagnation is

Due to:

Obstruction of urinary flow …. {=>In cases of enlarged prostate}

4) Deficiency of stone-forming inhibitors

Due to:

- **Citrate**, pyrophosphate, glycoprotein inhibit growth of calcium phosphate and calcium oxalate crystals
  In type I renal tubular acidosis, hypocitraturia leads to renal stones

Types of kidney stones

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

Calcium salt stones(VERYCOMMON)

- **80%** of kidney stones contain calcium
- The type of salt depends on 1-Urine pH 2-Availability of oxalate
- General appearance:
  - White, hard, radiopaque
  - Calcium PO4:STAGHORNin renal pelvis (large)
  - Calcium oxalate: present in ureter (small)

Calcium oxalate stone

MOSTLY → Calcium oxalate

Dr. Reemsallam said we don't have to memorize the numbers

Causes of calcium salt stones:

Calcium oxalate stones

- Hypercalciuria:
  - Increased urinary calcium excretion
  - Men: > 7.5mmols/day
  - Women > 6.2mmols/day
  - It may be due to hypercalcemia (most often due to 1^{ary} hyperparathyroism)
  - May or may not be due to hypercalcemia

- Hyperoxaluria: ⚠ Most important
  - Causes the formation of calcium oxalates WITHOUT HYPERCALCIURIA
  - Diet rich in oxalates
  - Increased oxalate absorption in fat malabsorption (Decrease fat absorption stimulates oxalate absorption)

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

Treatment:

- Treatment of primary causes such as infection, hypercalcemia, hyperoxaluria
- Oxalate-restricted diet (not recommended to reduce calcium in diet)
- Increased fluid intake(If no glomerular failure).
- Acidification of urine (by dietary changes)
  - Calcium salt stones are formed in alkaline urine ⚠

Uric acid stones

Uric acid stone

- 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 (Ultrasound with pyelogram which is a dye)

Uric acid stone

Treatment:

- Purine-restricted diet(⟹ because uric acid is the end product of purine)
- Alkalization of urine (by dietary changese.g. by potassium citrate)
- Increased fluid intake

Mg ammonium PO_4 stones

- About 10% of all renal stones contain Mg amm. PO4
- Also called **STRUVITE** kidney stones
- Associated with chronic urinary tract infection
  - Microorganisms (such as from Proteus genus) that metabolize urea into ammonia

Bacteria interacts and transformation of urea to ammonium which binds with magnesium and phosphate to form stones

  - Causing urine pH to become alkaline and stone formation

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

Treatment:

- Treatment of infection
- Urine acidification
- Increased fluid intake
- It may require complete stone removal (percutaneous nephrolithotomy) ⟹ (because stones may grow larger in size)

Struvite stone

Cystine stones

- A rare type of kidney stone
- Due to homozygous cystinuria(⟹ Inborn error of amino acid metabolism(genetic))
- Form in acidic urine
- Soluble in alkaline urine
- Faint radio-opaque

Cystine stone

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

Stone is available (with urine or by surgical intervention)

Chemical analysis of stone helps to:

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

Stone is not available (meaning we don't have it, it's in the patient)

Blood analysis: calcium, uric acid, [PTH]

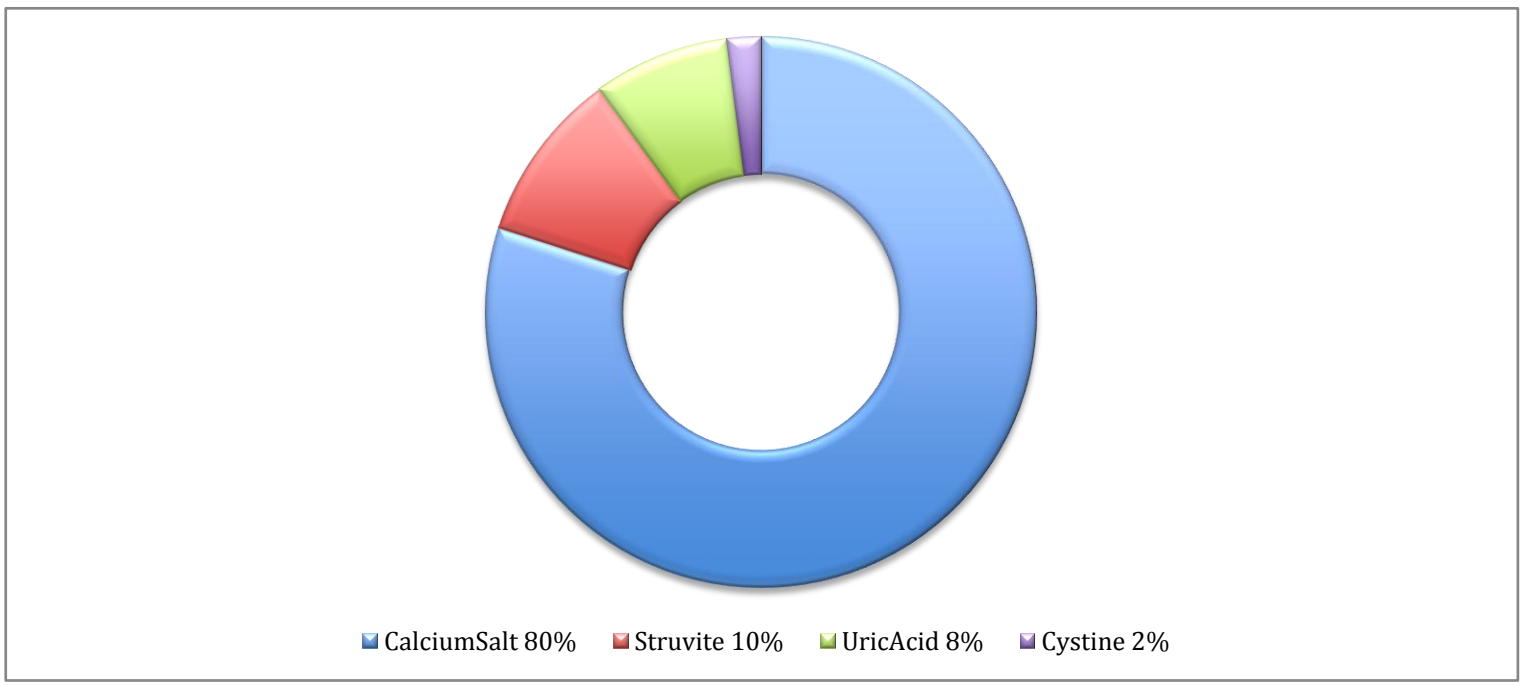
Urine analysis: volume, calcium & oxalate

Urine pH:> 8 suggestive of urinary tract infection (Mg amm. phosph.)

Screening of urine for cystine: qualitative (if +ve: collect *24 hours urine*)

(qualitative means it only give yes or no result indicating if there is cystine or not)

Renal tract imaging: CT, ultrasonography & I.V. pyelogram



Questions for Review

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 is treated by alkaline urine:-
   a) Calcium salt stones
   b) Cystine stones
   c) Mg ammonium PO4 stones
   d) A, C

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

4. 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

5. 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 = B }{ 3 = C }{ 4=A }{ 5 = C }