Kidney Stones

Renal Block

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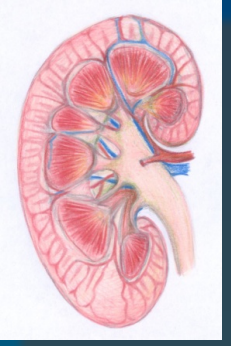
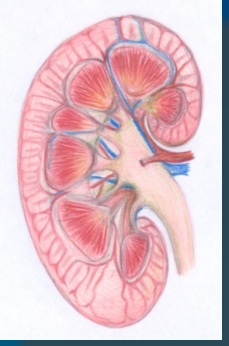


Objectives

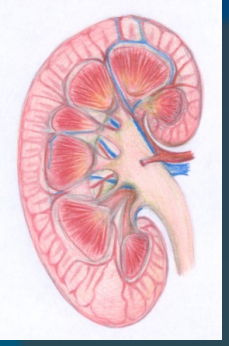
By the end of this lecture, the students will be able to:

- 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



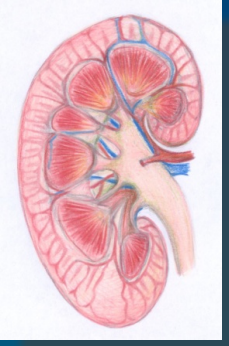
Overview

- Introduction
- Conditions causing kidney stone formation
- Types of kidney stones
  - Calcium salts
  - Uric acid
  - Mg ammonium PO_4
  - Cystine
  - Other (xanthine, etc.)
- Laboratory investigations



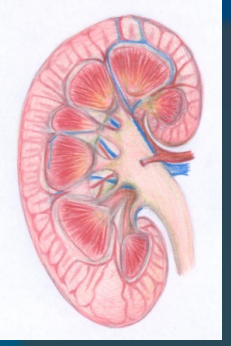
What are kidney stones?

- 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



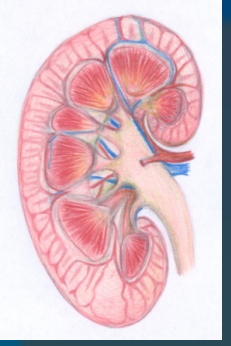
Conditions causing kidney stone formation

- High conc. of metabolic products in glomerular filtrate
- Changes in urine pH
- Urinary stagnation
- Deficiency of stone-forming inhibitors in urine



Conditions causing kidney stone formation

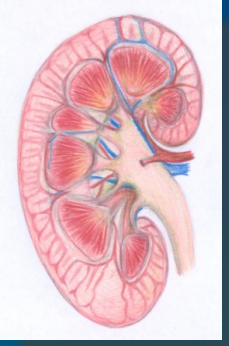
- High conc. of metabolic products in glomerular filtrate is due to:
  - Low urinary volume (with normal renal function) due to restricted fluid intake
  - Increased fluid loss from the body
  - Increased excretion of metabolic products forming stones
  - High plasma volume (high filtrate level)
  - Low tubular reabsorption from filtrate



Conditions causing kidney stone formation

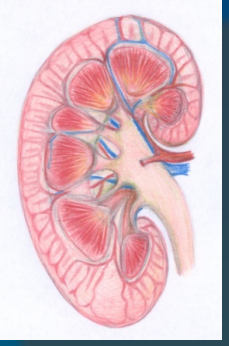
- Changes in urine pH due to:
  - Bacterial infection
  - Precipitation of salts at different pH
    - A persistently **acidic** urine → promotes **uric acid** precipitation
    - A persistently **alkaline** urine (due to upper urinary tract infection)→ promotes **Mg Ammonium Phosphate** crystals (Struvite stones)

- Urinary stagnation is due to:
  - Obstruction of urinary flow



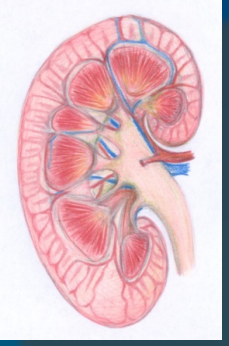
Conditions causing kidney stone formation

- Deficiency of stone-forming inhibitors:
  - Citrate, pyrophosphate, glycoproteins 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.)



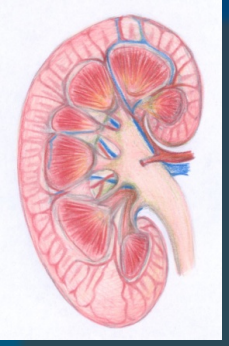
Calcium salt stones

80% of kidney stones contain calcium:

Mostly Ca-Oxalate and less often Ca-Phosphate

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

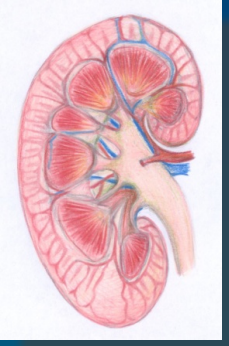
- General appearance:
  - White, hard, radio-opaque
  - Calcium oxalate: present in ureter (small)
  - Calcium PO_4: staghorn in renal pelvis (large)



Calcium salt stones

Causes of calcium salt stones:

- **Hypercalciuria:**
  - Increased urinary calcium excretion
  - Men: > 7.5 mmols/day
  - Women > 6.2 mmols/day
  - Due to hypercalcemia (most often due to 1^{ary} hyperparathyroism)
  - sometimes, Ca^{++} salts stones are found with no hypercalcemia

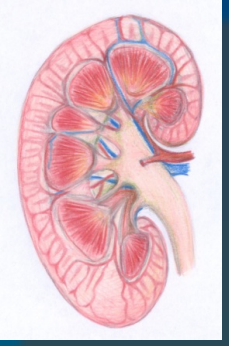


Calcium salt stones

- **Hyperoxaluria:**
  - Causes the formation of calcium oxalates without hypercalciuria
  - Diet rich in oxalates
  - Increased oxalate absorption in fat malabsorption

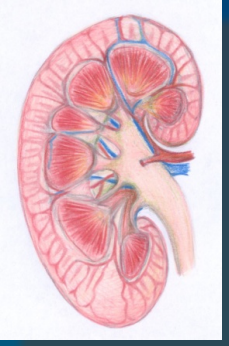
- **Primary hyperoxaluria:**
  - Due to inborn errors
  - Urinary oxalate excretion: > 400 µmol/24 Hours

Calcium oxalate stones



Calcium salt stones

- **Treatment:**
  - Treatment of primary causes such as infection, hypercalcemia, hyperoxaluria
  - Oxalate-restricted diet
  - Increased fluid intake (if no glomerular failure)
  - Acidification of urine (by dietary changes)
    - Calcium salt stones are formed in alkaline urine

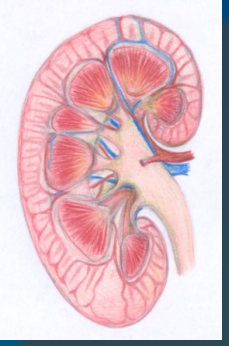


Uric acid stones

- 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

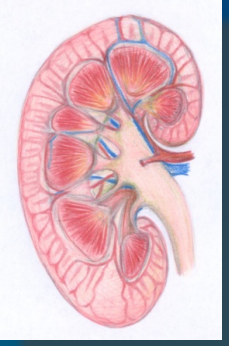
Uric acid stones



Uric acid stones

Treatment:

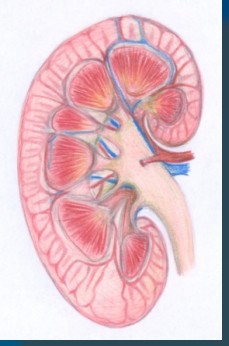
- Treatment of cause of hyperuricemia.
- Purine-restricted diet
- Alkalinization of urine (by dietary changes)
- Increased fluid intake



Mg ammonium PO_4 stones

- 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
  - Causing urine pH to become alkaline leading to stone formation
- Commonly associated with staghorn calculi
- 75% of staghorn stones are of struvite type

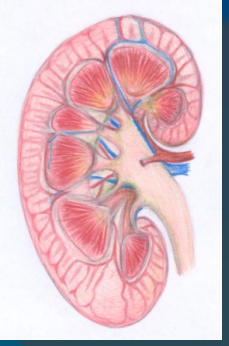
Mg ammonium phosphate (struvite) stone



Mg ammonium PO_4 stones

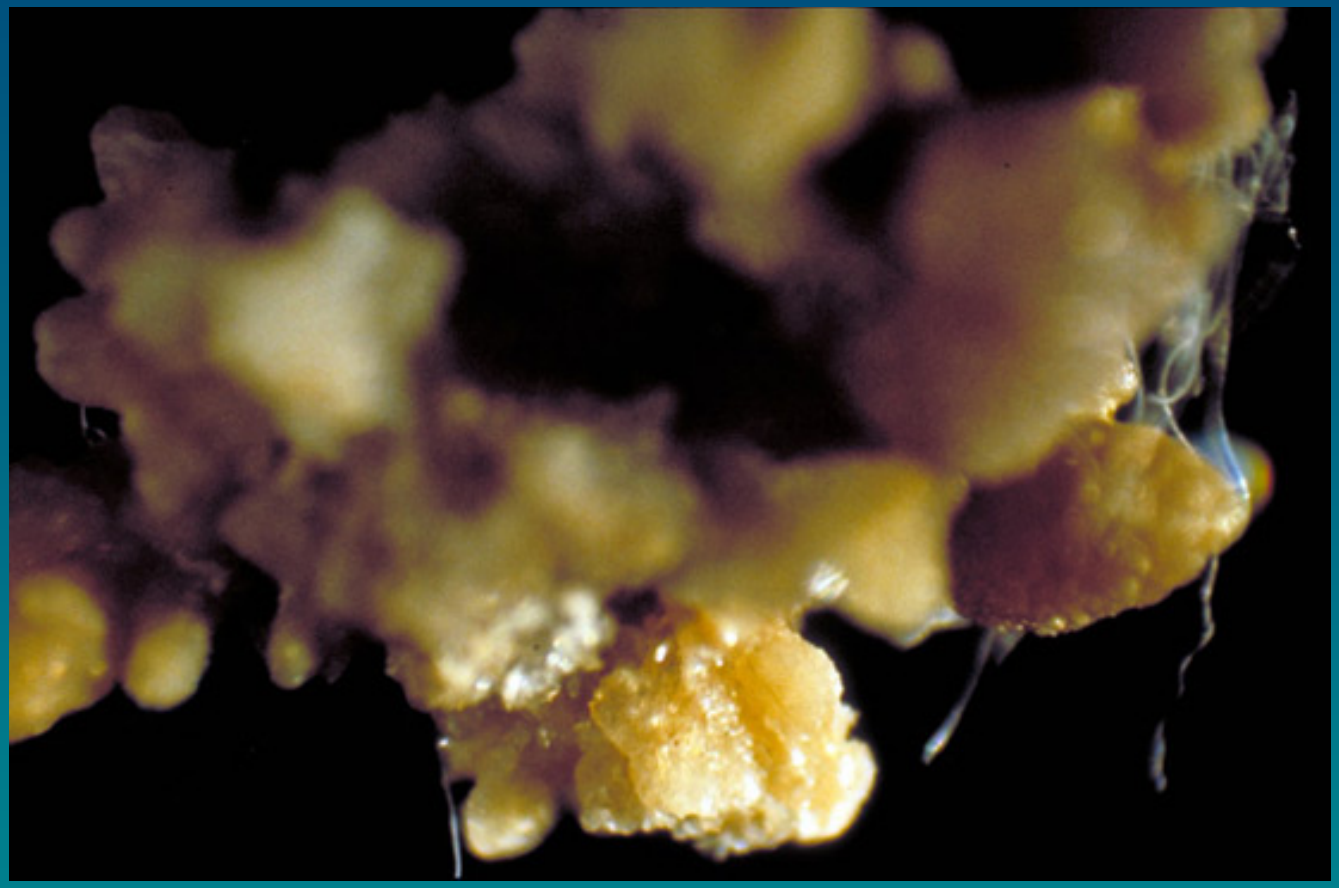
Treatment:

- Treatment of infection
- Urine acidification
- Increased fluid intake
- In some cases, it may require complete stone removal (percutaneous nephrolithotomy)

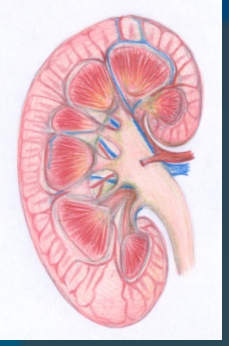


Cystine stones

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



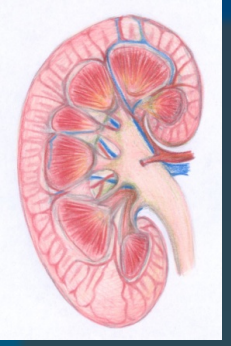
Cystine stone



Cystine stones

Treatment:

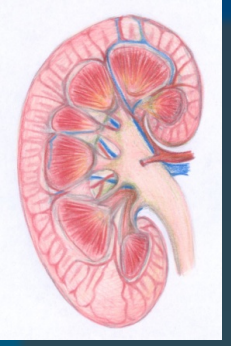
- Increased fluid intake
- Alkalinization of urine (by dietary changes)
- Penicillamine (binds to cysteine to form a compound more soluble than cystine)



Laboratory investigations of kidney stones

If stone has formed and removed:

- **Chemical analysis of stone helps to:**
  - Identify the cause
  - Advise patient on prevention and future recurrence

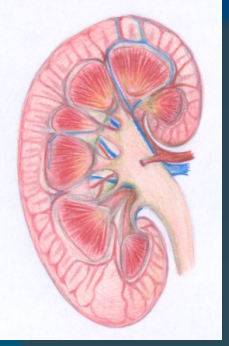


Laboratory investigations of kidney stones

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)

- **Urinary tract imaging:**
  - CT, ultrasound and i.v. pyelogram



References

- Clinical Chemistry and metabolic Medicine 7th Edition, pp. 36.
- The National Kidney Foundation, USA (www.kidney.org)