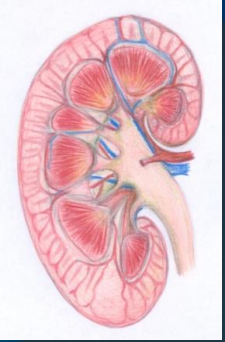


Kidney Stones

Renal Block

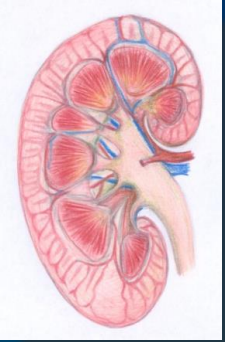
1 Lecture



Objectives

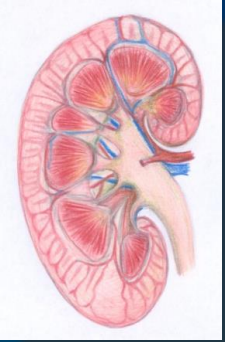
By the end of this lecture, the students will be able to:

- 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



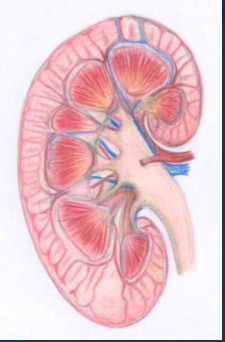
Overview

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



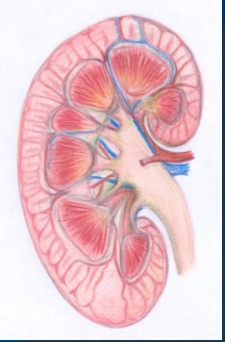
What are kidney stones?

- 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



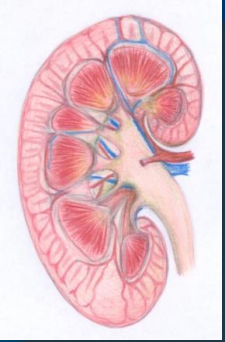
Conditions causing kidney stone formation

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



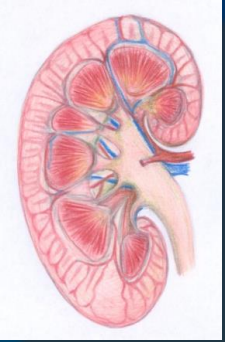
Conditions causing kidney stone formation

- 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



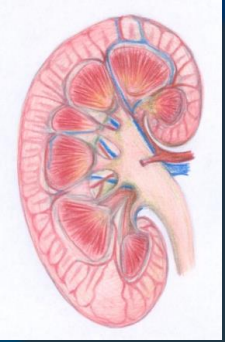
Conditions causing kidney stone formation

- 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



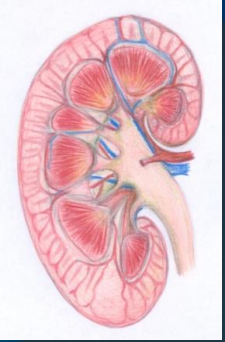
Conditions causing kidney stone formation

- 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 PO₄
- Cystine
- Other (xanthine, etc.)



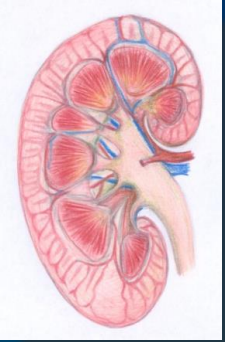
Calcium salt stones

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)

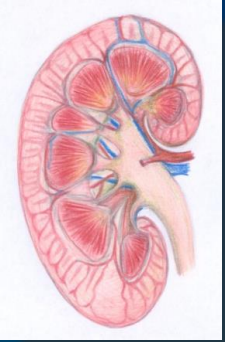


Calcium salt stones

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} hyperparathyroidism)
- sometimes, Ca^{++} salts stones are found with no hypercalcemia



Calcium salt stones

■ Hyperoxaluria:

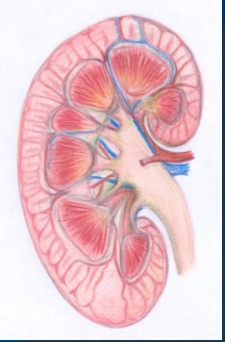
- Causes the formation of calcium oxalates without hypercalciuria
- Diet rich in oxalates
- Increased oxalate absorption in fat malabsorption

■ Primary hyperoxaluria:

- Due to inborn errors
- Urinary oxalate excretion: $> 400 \mu\text{mol}/24 \text{ Hours}$



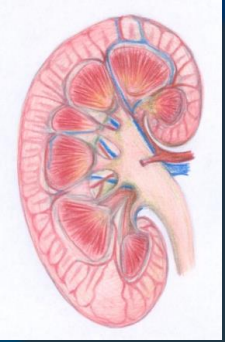
Calcium oxalate stones



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



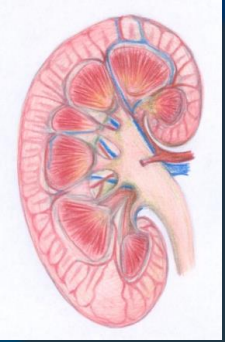
Uric acid stones

- 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



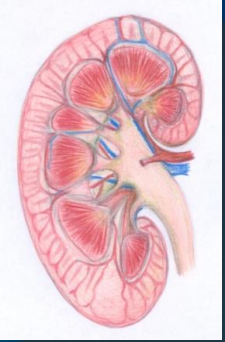
Uric acid stones



Uric acid stones

Treatment:

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

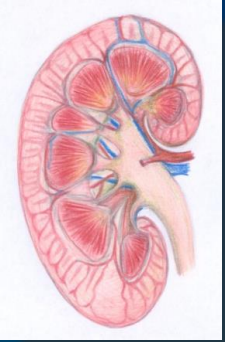


Mg ammonium PO_4 stones

- 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



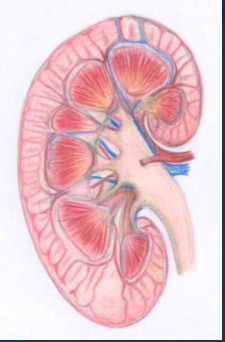
Mg ammonium phosphate (struvite) stone



Mg ammonium PO₄ stones

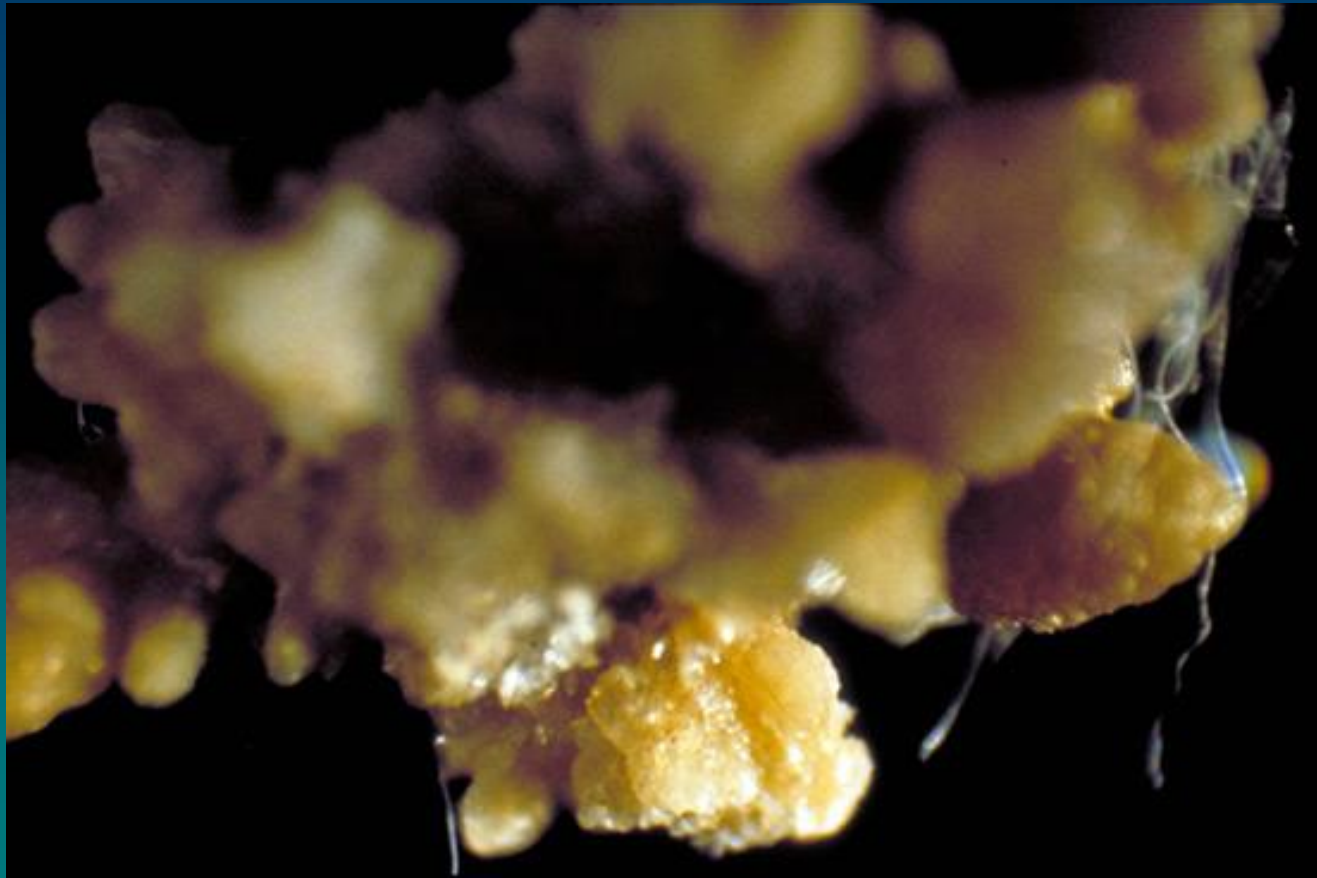
Treatment:

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

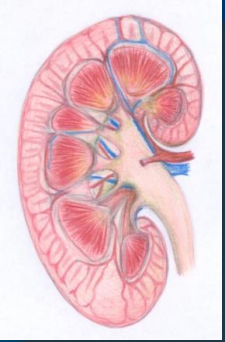


Cystine stones

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



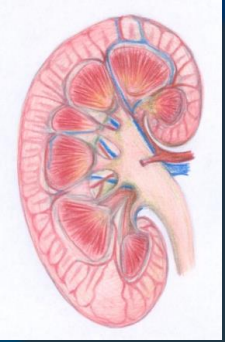
Cystine stone



Cystine stones

Treatment:

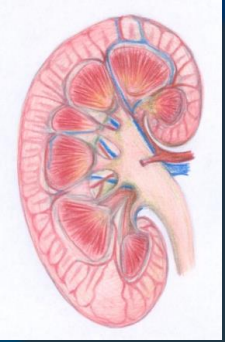
- Increased fluid intake
- Alkalinization of urine (by dietary changes)
- Penicillamine (binds to cysteine to form a compound more soluble than cystine)



Laboratory investigations of kidney stones

If stone has formed and removed:

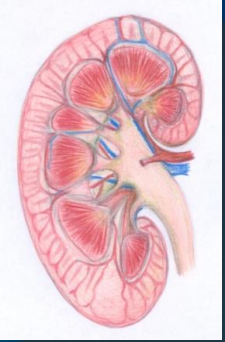
- **Chemical analysis of stone helps to:**
 - Identify the cause
 - Advise patient on prevention and future recurrence



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. PO₄)
- **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)