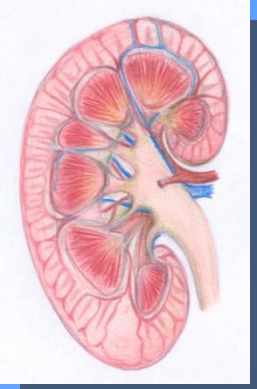
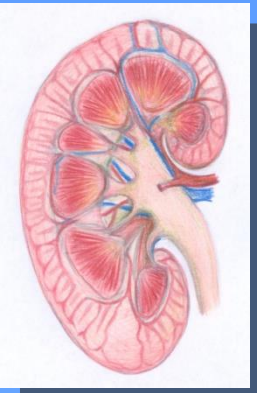


Renal Block

Clinical Chemistry Lectures

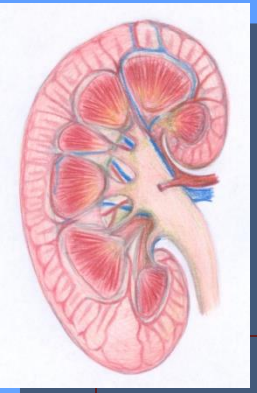
KIDNEY STONES

By: Reem M Sallam, MD, MSc, PhD



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.



What are kidney stones ?

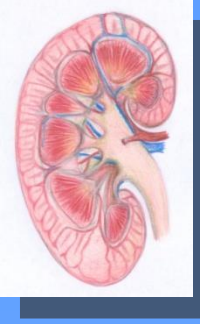
Kidney stones (renal calculi)

are stones that are formed in renal tubules

&

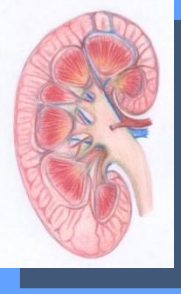
are usually composed of products of metabolism present in normal glomerular filtrate

often at concentrations near their maximum solubility



Conditions favouring kidney stones formation

1. High urinary concentrations of constituents of glomerular filtrate
2. Change in pH of urine
3. Urinary stagnation
4. Lack of normal inhibitors of stone formation in urine



Conditions favouring kidney stones formation

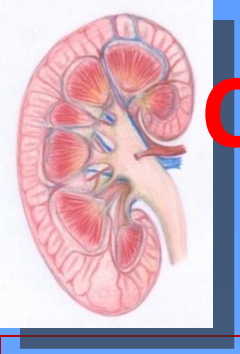
1- High urinary concentrations of one or more constituents of glomerular filtrate due to:

- ↓urinary volume (with normal renal function)

- Restricted fluid intake
- ↑fluid loss over a long period of time

- ↑ rate of excretion of metabolic products forming stones

- ↑ plasma volume (that increases filtrate level)
- ↓ tubular reabsorption from filtrate



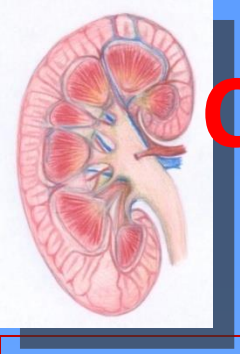
Conditions favouring kidney stones formation (cont.)

2- Change in pH of urine

- often due to bacterial infection
- ↑ precipitation of different 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)

3- Urinary stagnation:

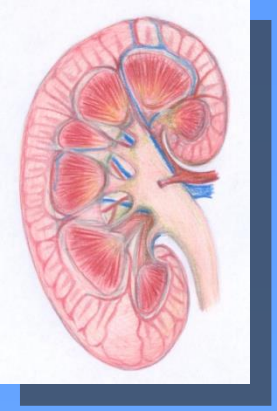
- Due to obstruction of urinary outflow



Conditions favouring kidney stones formation (cont.)

4- Lack of normal inhibitors in urine

- Inhibitors of stone formation: e.g.:
  - **Citrates**
  - Pyrophosphate
  - Glycoproteins
- Inhibit the growth of Ca^{++} salts crystals
- In type I renal tubular acidosis, hypocitraturia →renal stones



Constituents of Kidney Stones

1- Stones of calcium salts

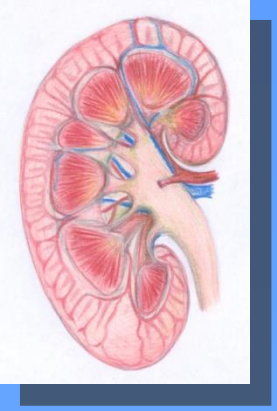
2- Uric Acid stones

3- Magnesium ammonium phosphate stones

4- Cystine stones

5- Others (xanthine, etc)

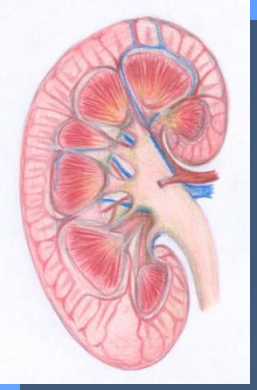
Stones of Calcium Salts
e.g. Calcium Oxalate Stones



Constituents of Kidney Stones:

1-Stones of calcium salts

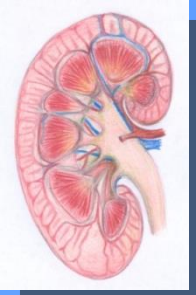
- **80%** of patients with nephrolithiasis form calcium stones:
  - Mostly: Ca-Oxalate
  - Less often: Ca-Phosphate
- **Type of salt depends on**:
  - pH of urine &
  - Availability of oxalate



Constituents of Kidney Stones:

1-Stones of calcium salts (cont.)

- **Characters:**
  - white, hard & radio-opaque
  - Ca-Oxalate: smaller, lodge in ureter
  - Ca-Phosphate: staghorn, in renal pelvis (big)



Constituents of Kidney Stones:

1-Stones of calcium salts (cont.)

Main causes favouring formation of calcium salts stones:

1- Hypercalciuria:

Defined as daily urinary Ca excretion >6.2 mmol in ♀ & >7.5 mmol in ♂

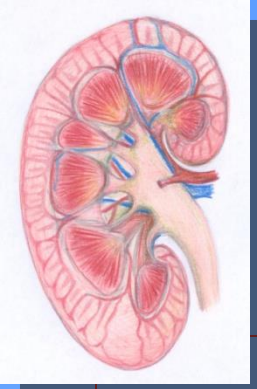
- due to hypercalcemia (most often due to 1^{ary} hyperparathyroism)
- sometimes, Ca^{++} salts stones are found with no hypercalcemia

2- Hyperoxaluria (more important)

- favours formation of calcium oxalates (even with no hypercalciuria)

- causes:

  - exogenous (diet rich in oxalate)
  - ↑absorption (in fat malabsorption)
  - 1^{ary} hyperoxaluria: inborn errors , in childhood , urinary oxalates > 400 μmol/24 hours



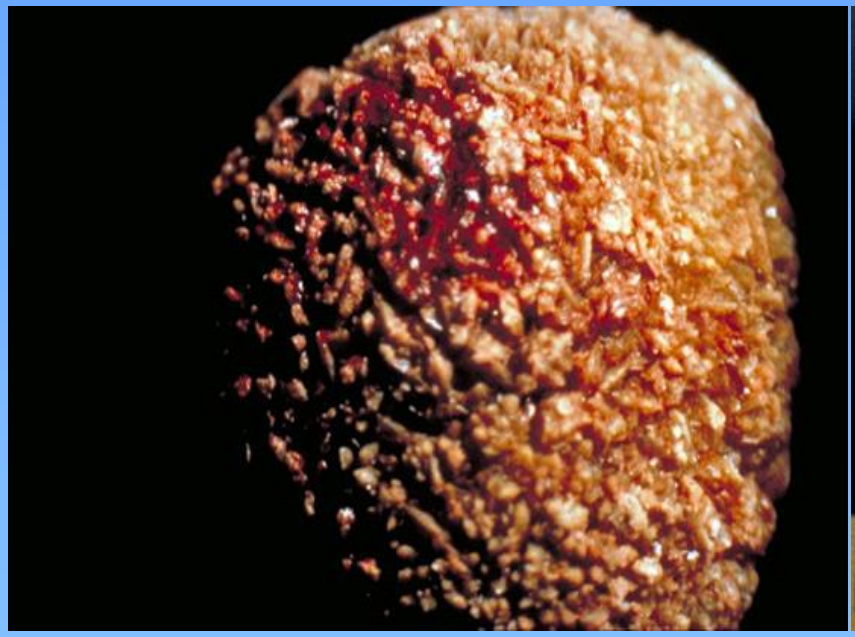
Constituents of Kidney Stones:

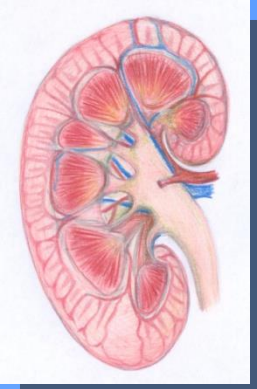
1-**Stones of calcium salts** (cont.)

Conservative lines of treatment:

- **Treatment of primary condition** (i.e. Infection, hypercalcemia, hyperoxaluria)
- **Reducing oxalates in diet** (it is not recommended to reduce calcium in diet)
- ↑ **Fluid intake** (if no glomerular failure).
- **Acidification of urine** (as ppt. is favoured by alkaline conditions)

Uric acid stones

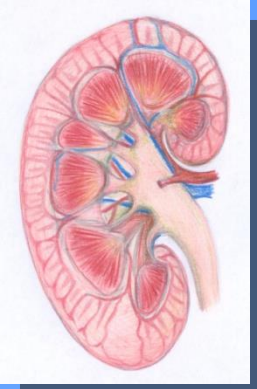




Constituents of Kidney Stones:

2-Uric acid stones

- **~ 8%** of renal stones contains uric acid
- may be associated with **hyperuricemia** (with or without clinical **gout**)
- **Acidification of urine**→ favours Uric acid precipitation
- **Characteristics**:
  - small, friable & yellowish
  - may form staghorn (if big)
  - radiolucent (can't be seen be plain X-ray)
  - visualized by ultrasonography or I.V. Pyelogram

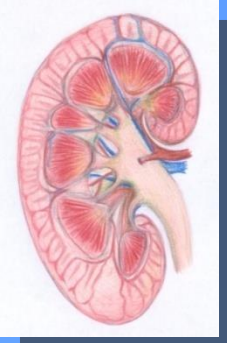


Constituents of Kidney Stones:

2-Uric acid stones, (Cont.)

- **Treatment**:
  - Treatment of cause of hyperuricemia
  - ↓ purine-rich diet
  - Alkalinzation of urine (e.g. by potassium citrate)
  - ↑fluid intake

Mg ammonium phosphate (struvite) stone

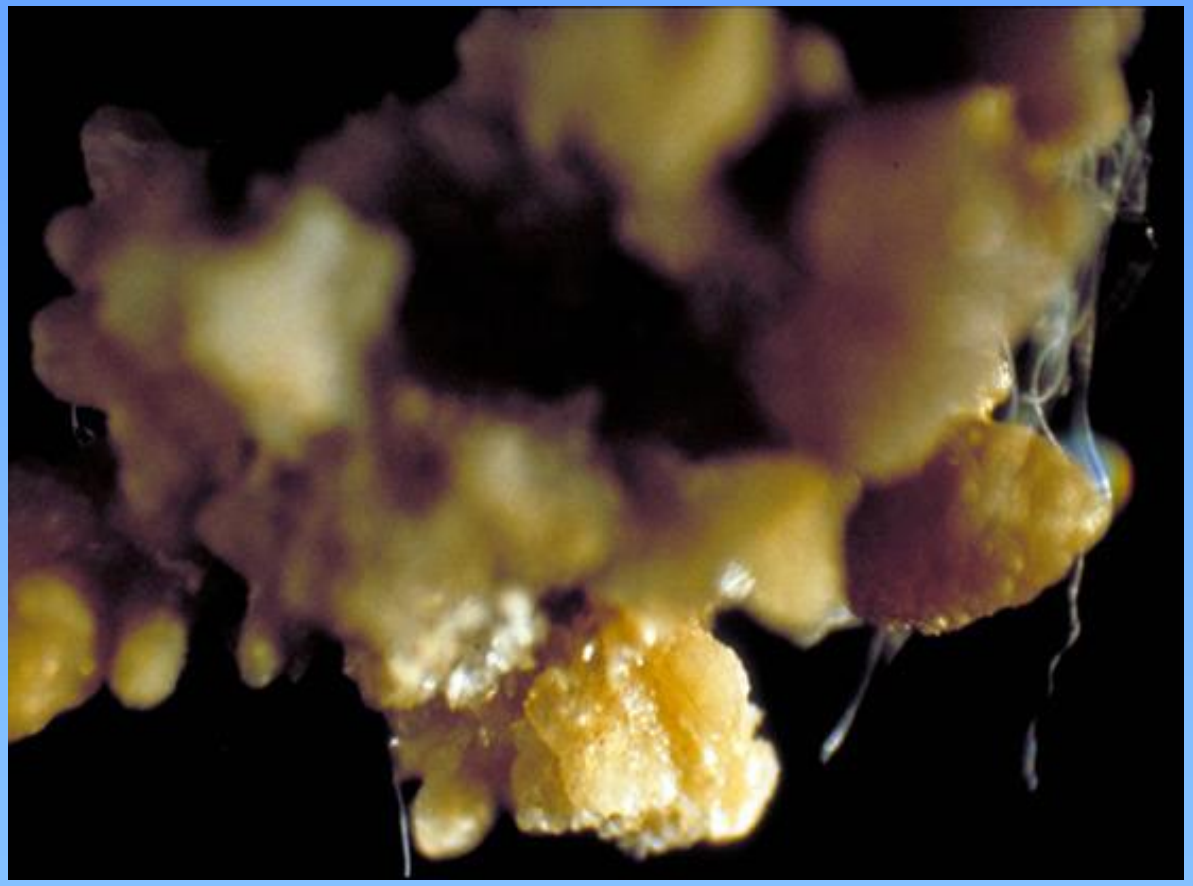


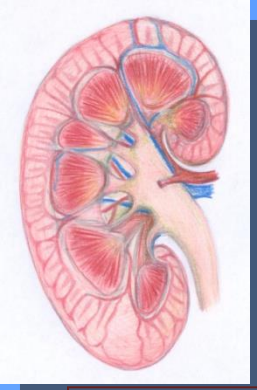
Constituents of Kidney Stones:

3- Magnesium ammonium phosphate stones

- **~ 10%** of all renal stones
- With chronic urinary tract infection (by urease splitting oraganisms as *Proteus* species → ammonia production from urea)
- Alkaline urine pH (> 7.0)
- **Treatment:**
  - Aggressive prevention & treatment of the cause (urinary tract infection)
  - Urine acidification
  - ↑ Fluid intake
  - It may require complete stone removal (percutaneous nephrolithotomy)
  - Aggressive prevention & treatment of future urinary tract infection

Cystine stones

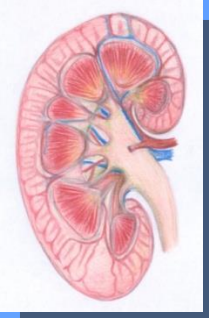




Constituents of Kidney Stones:

4- **cystine stones**

- Rare
- occurs in cases of homozygous **cystinuria** (inborn error of amino acid metabolism)
- Soluble in alkaline urine (precipitates by acidic urine)
- **Treatment**:
  - ↑ fluid intake
  - Alkalinzation of urine
  - Penicillamine



Investigations of patients with renal calculi

1- Stone is <u>available</u> (with urine or by surgical intervention)

laboratory investigations for detection of stone *chemical constituents:*

- to know the cause
- for decision of lines for preventive treatment

2- Stone is <u>not available</u>

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: *24 hours urine*)

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

To summarize: Evaluation & subsequent treatment

- Retrieve stones and send for analysis.
- Subsequent therapy depends on stone & biochemical abnormalities.
- ***ALL patients should increase fluid*** intake to > 2L/day
- Do a complete evaluation in certain patients (those with moderate-high risk:
    - Middle-aged, White, Males, with + ve Family History
    - Patients with chronic diarrheal states and/or malabsorption, pathological fractures, osteoporosis, UTIs, or gout.
    - Patients with certain types of stones:
        - e.g. stones composed of calcium phosphate (hard stone) or struvite (@ risk for staghorn calculi)

THANK YOU