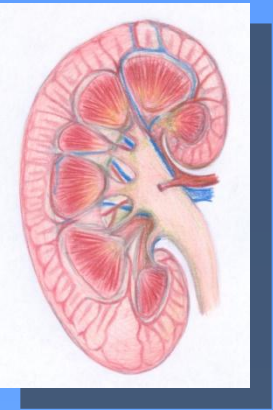


Renal Block

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

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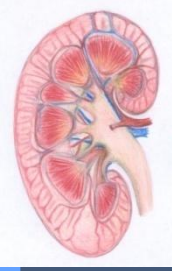
are usually composed of products of metabolism
present in normal glomerular filtrate

often at concentrations near their maximum solubility



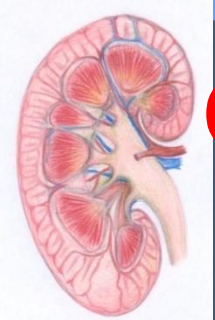
Conditions favouring kidney stones formation

- 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



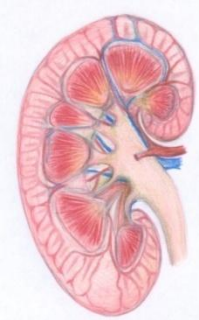
Conditions favouring kidney stones formation (cont.)

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:

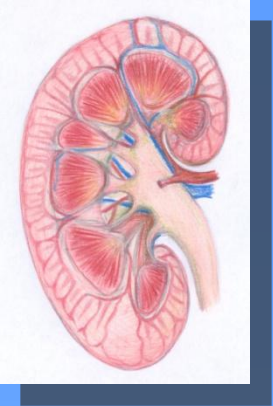
- Due to obstruction of urinary outflow



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

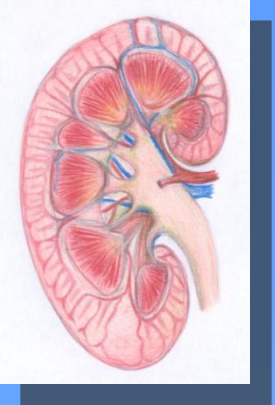


Constituents of Kidney Stones

- 1- Stones of **calcium** salts
- 2- **Uric Acid** stones
- 3- **Magnesium ammonium phosphate** stones
- 4- **Cystine** stones
- 5- Others (xanthine, etc)

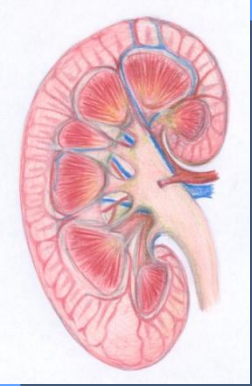
Stones of Calcium Salts e.g. Calcium Oxalate Stones





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} hyperparathyroidism)
- 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 $\mu\text{mol}/24$ hours



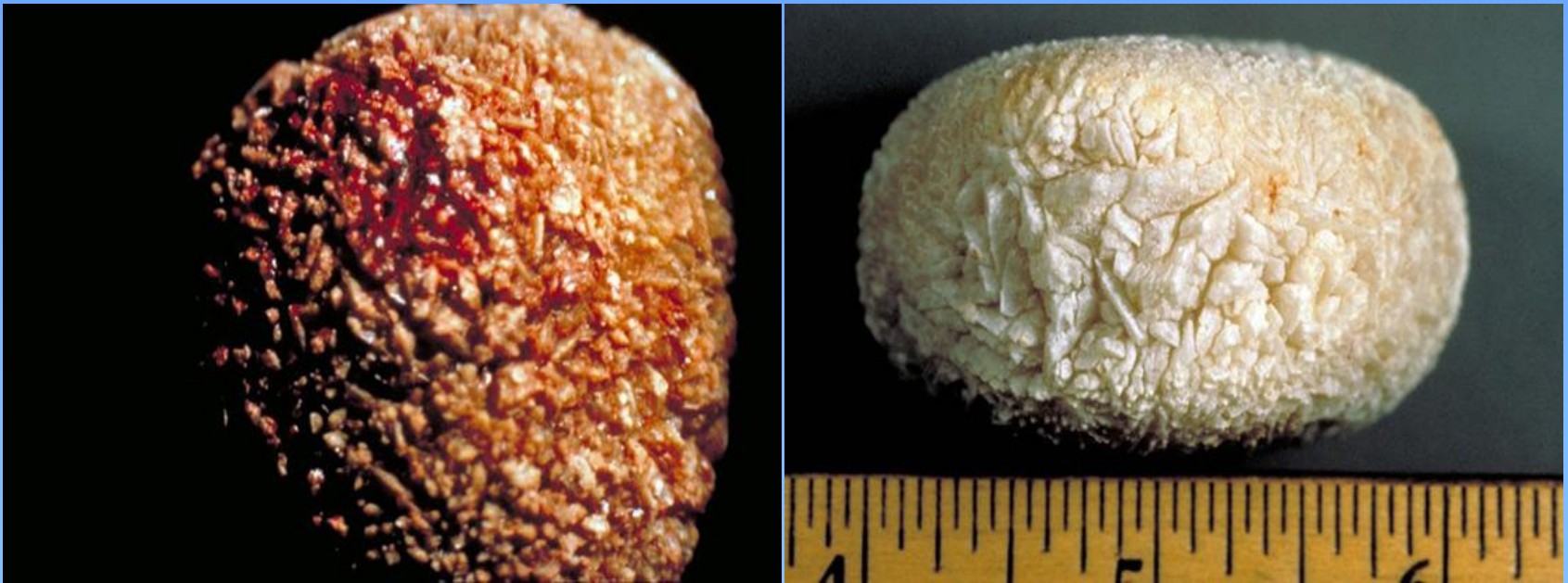
Constituents of Kidney Stones:

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

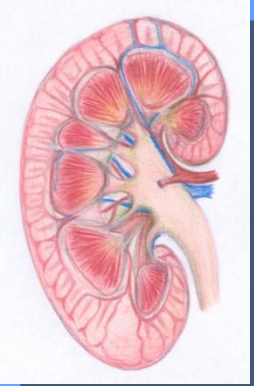




Constituents of Kidney Stones:

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 on 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
 - Alkalinization of urine (e.g. by potassium citrate)
 - ↑ fluid intake

Mg ammonium phosphate (struvite) stone



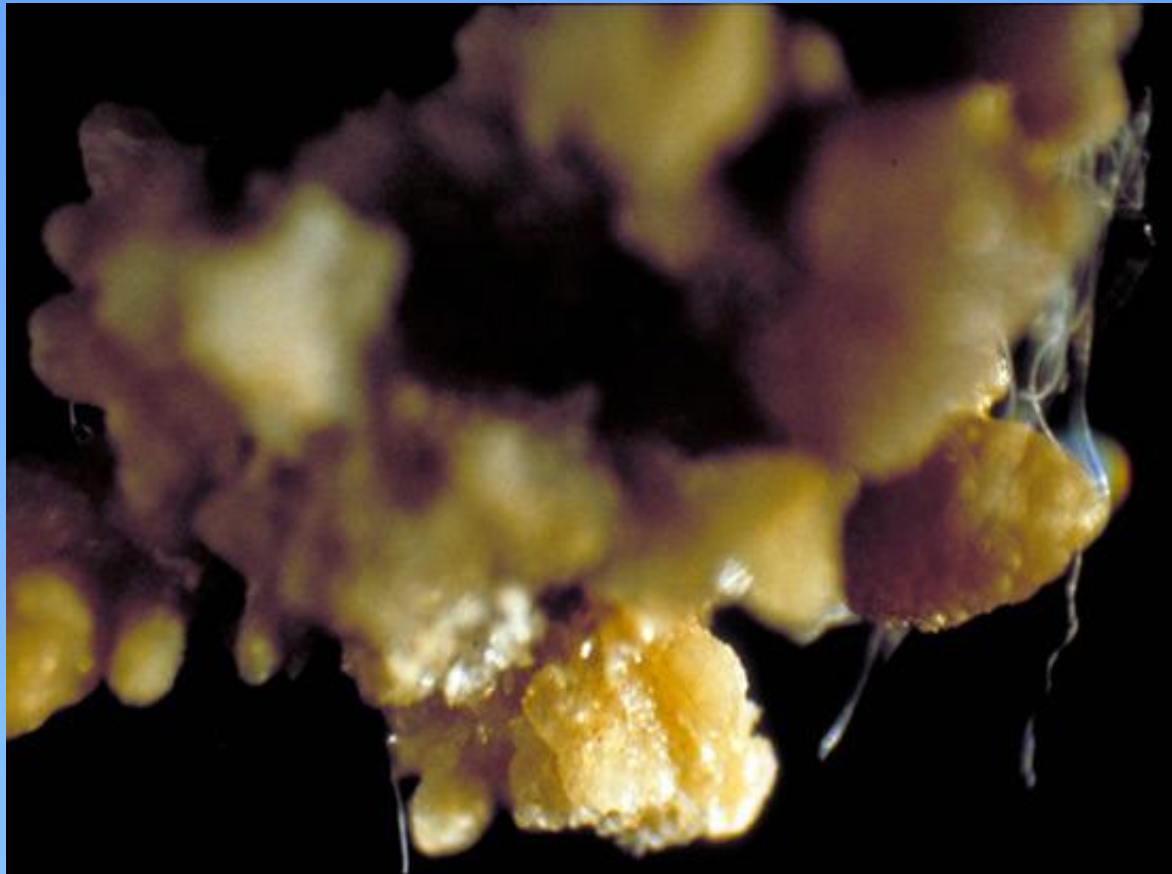
Constituents of Kidney Stones:

3- Magnesium ammonium phosphate stones



- ~ 10% of all renal stones
- With chronic urinary tract infection (by urease splitting organisms 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
 - Alkalinization of urine
 - Penicillamine



Investigations of patients with renal calculi

1- Stone is available (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 not available

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