Lecture 54

Renal stones (Urolithiasis)

Objectives:

1. Mention the normal urinary pH& describe how its changes can help in diagnosing type of urinary stone.
2. List the main chemical types of urinary stones.
3. Mention the radiologic appearance of these stones.
4. Describe different shapes of urine crystals associated with each type of stone.
5. Explain the pathological condition, metabolic disorder that lead to the formation of these stones.

Urinary pH:

Normal mixed urine for 24 hours is generally acidic (pH 5.0 – 6.5), the actual [H^+] ranges from pH 4.8 to 8.0 with mean value of pH 6.0 The pH of urine is a mean of a large number of acidic and basic constituents, of both organic and inorganic, e.g., the mono- and dibasic sodium and potassium phosphates (NaH_2PO_4 and Na_2HPO_4). Excretion of acid or alkaline phosphate by the kidneys is one of the regulatory mechanisms by which the organism regulates the pH of systemic blood.

- **Physical exercise:** produces an increase in [H^+] and ammonia output.
- **Pathological conditions:** The mean acidity in cardio-renal diseases is high (about pH 5.3) as compared with normal mean (pH 6.0). Generally most pathological diseases are associated with further acidity of urine.
- **The composition of food**: is perhaps one of the factors that determine pH of urine. For instance, for a variable length of time after a meal the urine may be neutral or even alkaline. Secretion of gastric juice for digestive function, causes alkaline urine, known as the alkaline tide.
- The urine may also become temporarily alkaline as a result of ingesting alkaline carbonates or certain salts of tartaric and citric acids

which are metabolized into bicarbonate. Frankly, ingestion of acid fruits such as oranges, lemons, peaches cause the formation of alkaline urine because they lead to formation of sodium bicarbonates. On the other hand ingesting of bread, cereals, meat yield acidic urine.

- **Normal urine on standing**: becomes alkaline owing to alkaline or ammoniacal fermentation through the action of microorganisms.
- **During infection**, urine has undergone this change within the body and is voided in the decomposed state. Ammonical fermentation is ordinarily due to cystitis or occurs as the result of infection in the process of chathetarization. A microscopic examination of such urine shows the presence of ammonium magnesium phosphates crystals, amorphous phosphates and not infrequently ammonium urate.

Introduction about urinary stones:

Stone formation can take place anywhere in the urinary collecting system (most commonly in the collecting duct) and largely depends on sex, age, diet, climate, and genetic makeup. Their size can vary from crystals to large stones. They occur more commonly in men and in the summer due to insufficient fluid intake.

The formation of stone ultimately depends on the formation of crystalluria which may results from:

1- Metabolic disease.
2- Low urine volume.
3- Variation in urine pH, e.g. calcium precipitates in an alkaline urine, whereas uric acid and cystine precipitates in an acidic urine.
4- Urinary stasis, e.g. obstruction, malformations.
5- Lack of inhibitors (Evidence suggests that normal urine contains a number of inhibitors which preclude stone formation e.g. mucopolysaccharides, citrate and pyrophosphate).

There are several different chemical types:

1. **Calcium oxalate stones** are the most common. They can form from a high concentration of calcium in the urine (hypercalicuria) that is caused by excess GI absorption, excess renal excretion, and/or excess bone resorption.

They can also form with hyperoxaluria (eg, hereditary primary hyperoxaluria (Defective glycine metabolism), high vitamin C intake, inflammatory bowel disease, or as a result of ethylene glycol [antifreeze] ingestion, hypocitraturia (leading to decreased urinary pH).

2. **Calcium phosphate stones** are the next most common and often occur in the setting of immobilization or bone-mineral disease. Examples are hypercalcemia secondary to hyperparathyroidism, vitamin D intoxication, milk alkali syndrome and sarcoidosis.
3. **Struvite (magnesium ammonium phosphate) stones** occur in patients with persistently alkaline urine from urinary tract infections (UTIs) caused by **urease-positive** organisms, such as *Proteus vulgaris,* staphylococci, *Klebisella,* and *Pseudomonas* (but **not** *Escherichia coli*). The urine pH is alkaline. When the stone creates a cast of the renal pelvis and calyceal system, it is referred to as a **staghorn kidney stone.**
4. **Uric acid stones** are associated with **gout** or diseases that cause rapid cell turnover (**leukemia,** myeloproliferative diseases). They are more likely to form in **acidicurine.**

N.B. Uric acid is the end product of catabolism of purines in man. Its amount in urine is normally about 0.7 gm/day. Half of it is of exogenous origin produced from nucleoproteins taken in diet, while the other half is of endogenous origin produced from catabolism of nucleoproteins in the body.

5. **Cystine stones** are seen in patients with genetic defects in the proximal convoluted tubules reabsorption of cystine, ornithine, lysine, or arginine. They are more likely to form in **acidic urine.**

Presentation:

Kidney stones classically present with severe flank pain that **radiates to the groin** and is colicky in nature. **Hydronephrosis**and **infection** proximal to the site of obstruction can occur as a result of prolonged impediment of the urine outflow.

Diagnosis:

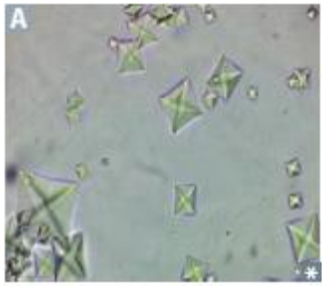
■ **Colicky pain in flank radiating to the groin,** nausea, vomiting, patient constantly moves to relieve pain.

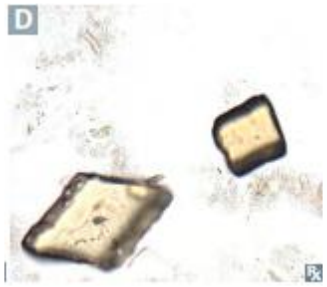
■ An**abdominal radiograph (Plain X-ray)** is helpful in cases of calcium oxalate, calcium phosphate, and struvite stones (which are **radiopaque**) but is of no value for uric acid and cystine stones, which are **radiolucent** and cannot be visualized on a radiograph. Thus, **noncontrast CT** is valuable in diagnosing such cases.

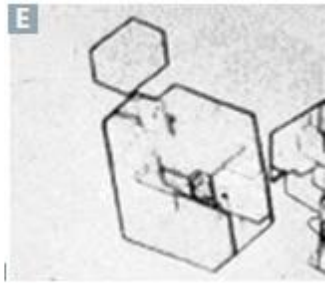
■ **Urinalysis**is likely to show hematuria. Also, type of urinary crystals may help to determine type of stone.

Treatment:

- Mainly depends on the type and size of stones (see Table).
- **Increased fluid intake** and appropriate **pain management** while waiting for the stone to pass is sufficient forstones smaller than 5 mm.
- Stones from 5 to 9 mm in diameter usually require medicalmanagement with alpha blockers (tamsulosin) to facilitate stone passage.
- Larger stones(> 9 mm in diameter) may require extracorporeal shockwave **lithotripsy** (ESWL) or surgical treatment **(nephrolithotomy).**
- Prevention strategies include drinking morewater, and other dietary and medication therapies depending on the type of stone (seeTable).
- Alkalization of the urine can be useful for treating uric acid and cystinestones, but this may cause the formation of calcium phosphate stones.
- Decreasingcalcium intake is not advised, since doing so may lead to greater oxalate absorption.

Stone type	Frequency	Causes	Radiology	Appearance	Treatment
Calcium oxalate	**Most common in adults and in children**	**Idiopathic, hypercalciuria, hyeroxaluria, hypocitraturia**	**Radiopaque**	**Envelope or ectahedron** 	**Low sodium diet to reduce hypercalciuria, sufficient citrate in diet, low oxalate diet (no chocolate, nuts) and if necessary thiazide diuretics to reduce hypercalciuria**
Calcium phosphate	**common in individuals with bone mineral disease or immobilization**	**immobilization, cancer, ↑PTH, ↑ vitamin D, milk alkali syndrome**	**Radiopaque**	**usually amorphous**	**Treat underlying disorder, low sodium diet and thiazide diuretics can reduce hypercalciuria**

Struvite (ammonium magnesium phosphate)	**Second most common**	**UTI with urease-positive bacteria (P vulgaris, staphylococcus, or klebsiella)**	**Radiopaque, stone creates a cast of the renal pelvis and calyceal system** 	**Rectangular prism, like coffin lids** 	**Surgical removal** **Antibiotics to eliminate bacteria, prevent UTI**
Uric acid	**Less common**	**Hyperuricemia: gout** **High cell turnover: leukemia and myeloproliferative diseases**	**Radiolucent**	**Yellow or red-brown, diamond or rhombus** 	**Allopurinol** **Alkalinize urine** **Limit purines in diet**

Cystine	**Least common**	**Cystinuria: genetic defect in PCT reabsorption of cystine, ornithine, lysine and arginine**	**Faintly opaque, ground glass**	**Flat, yellow hexagonal** 	**Increase fluid intake** **Alkalinize urine** **Low sodium diet** **Low protein diet**

PTH: Parathyroid hormone

UTI: Urinary tract infection