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A Clinical Review: Kidney Stone



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ABSTRACT

Kidney stone disease is a crystal concretion normally produced within kidneys. Kidney stones are the common cause of blood in the urine (hematuria) & often severe pain in the abdomen, flank, or groin. The medical term for a kidney stone is Urolithiasis, Nephrolithiasis. Nephrolithiasis is the condition of having a stone in the kidney. Having stone at any location in the urinary tract is referred to as urolithiasis & the term ureterolithiasis is referred to as stones located in the ureters. About 1% to 15% of worldwide people are affected by kidney disease. Kidney stones are of various types, of which calcium oxalate is the most common type. The mechanism of stone formation is a complex process that results from several physicochemical events including supersaturation, nucleation, growth, aggregation, and the retention of urinary stone constituents within tubular cells. Therefore, this review has intended to provide the compiled up-to-date information on kidney stone etiology, pathogenesis, and prevention approaches.



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INTRODUCTION

A kidney stone is the most common chronic kidney condition, after hypertension, & treatments for patients with stones have been described since the earliest medical texts. It has high morbidity & socioeconomic impact and low mortality. It affects up to 20% of the general population worldwide. Through the growth of civilization its frequency has risen and varies through the region, geographical areas, etc. Kidney stones are crystalline structures composed most commonly of calcium oxalate salt. They form when there are higher concentrations of ions, as well as solutes such as hydrogen ions, sodium ions, and uric acid in urine than normal count. This condition is known as supersaturation & supersaturated ions are more likely to come out of solution and crystallize. Supersaturation may result from dehydration, high fat diet, animal protein, high salt intake, and obesity.

Typically, crystals form in the distal tubule, nephron loop, and/or in the collecting system. Most crystals simply pass unnoticed into the urine. However, sometimes the crystals adhere to the epithelium of the tubules, particularly in the collecting system & form seed crystals that lead to the formation of stones. The stones may get collected in the collecting system or may break off & enter the calyces, renal pelvis, and ureter. Stones lodged within the urinary system cause occurrence of common symptoms such as severe pain and renal colic that radiates from the lumbar region to the pubic region.

EPIDEMIOLOGY

Renal stones, or nephrolithiasis, are a common problem worldwide. With its increasing prevalence, they are imposing a significant economic burden for both developing and developed nations. It has been observed that renal stones are associated with systemic diseases like Type 2 diabetes mellitus, obesity, dyslipidemia, and hypertension. Lifestyle and environmental factors contribute significantly to their formation. Presentation of renal colic is common and therefore treatment is not delayed. However, in the absence of any preventive measures >50% of renal stones may reoccur.

Renal stones can occur at any age; the peak incidence is reported in persons aged 20–49 years. Males are affected more than females. The prevalence of urinary tract stones in the industrialized world ranges from 4–20%. In India, 12% of the population is reported to be prone to uniform stone. Renal stones are common in obese and diabetic individuals. The recurrence rate of renal stones is high, with 50% recurring within 5 years of the initial stone

event. The factors that determine the accelerating pace of stone formation in recurrent stone formers are not well known. Therefore, in any single stone former, one cannot predict which patient will relapse, however, the natural history of stone disease and the high rate of recurrence requires careful diagnostic evaluation and early treatment. It is estimated that the incidence of renal stones may increase from 40% to 56% by 2050 as a result of the effects of global warming.

TYPES OF KIDNEY STONES

Calcium stone: -

Calcium stones are the most common types of stones found in the urinary tract. There are two types of calcium stones: calcium oxalate stone and calcium phosphate stone.

Calcium oxalates stone are crystalline components of calcium oxalate monohydrate, calcium oxalate dihydrate, and calcium oxalate trihydrate. Calcium oxalate acquires 75% of renal stones.

Calcium phosphate stone has crystalline components like hydroxyapatite, calcium hydrogen phosphate, dihydrate, an unusual form of calcium phosphate, tricalcium phosphate, ammonium magnesium, phosphate hexahydrate, ammonium magnesium, phosphate monohydrate, magnesium hydrogen, phosphate trihydrate, carbonate apatite, and octa calcium phosphate. It composes 5% of renal stones.

Calcium oxalate & calcium phosphate stones are ordinary with an abnormality in a urinary system like hypercalciuria, hypomagnesuria, hyperuricosuria, hyperoxaluria, and hypocitraturia.

Uric acid stone: -

Uric acid is a waste product that is synthesized from purine metabolism in the body. Uric acid stones are crystalline components of uric acid anhydrous and uric acid dehydrate, usually 5-15% of the analyzed population with renal stones are affected with uric acid stone. Around 25% of patients with this stone also suffer from gout disorder. Uric acid crystals are insoluble in acidic urine and form a uric acid stone. The acidic urine results from being overweight, chronic diarrhea, type 2 diabetes (high blood sugar), gout, a diet that is high in animal protein, and low in fruits and vegetables.

Cystine stone: -

Cystine is an amino acid that is in certain foods; it is one of the building blocks of protein. Cystinuria (too much cystine in the urine) is rare, inherited metabolic disorder. It is when the kidneys do not reabsorb cystine from the urine. When high amounts of cystine are in the urine, it causes stones to form. Cystine stones often start to form in childhood. 1% of people with renal stones are affected with cystine stones.

Struvite stones: -

Struvite stones are also called magnesium ammonium phosphate stones. These stones are related to chronic UTI (Urinary Tract Infections). Some bacteria make the urine less acidic and more basic or alkaline. In alkaline urine, struvite stones are formed. These stones are large, with branches, and often grow very fast. People who get chronic UTIs, such as those with long-term tubes in their kidneys or bladders, or people with poor bladder emptying due to neurologic disorders are at the highest risk for developing struvite stone. 10-20% of the analyzed population with renal stones are affected with struvite stone.

Table No. 1: Type of stones

Type	Frequency (%)	Sex	Crystal	Radiography
Calcium oxalate	75	M	Envelope	Round, radiodense, sharply outlined
Calcium phosphate	5	F>M	Amorphous: Alkaline urine	Small, radiodense, sharply outlined
Uric acid	5-15	M=F	Diamond; Acid urine	Round/ staghorn, radiolucent, filling defect
Struvite	10-20	F	Coffin lid; Infection	Staghorn, laminated radio dense
Cystine	1	M=F	Hexagon	Staghorn, radiodense

Courtesy from Dr. J. Seifter, Harvard Medical School, Renal Division Brigham and Women's Hospital, Boston



Figure No. 1: Crystal shapes of stones

PATHOPHYSIOLOGY

The pathogenesis of renal stone is complex to describe it encompassing several physicochemical events occurring sequentially or concurrently. Despite increasing study in the last decade, the mechanisms whereby calcium oxalate crystals are retained in the kidney and form renal stones remain incompletely understood.²³ Formation of stone required supersaturated ionic urine. The level of super-saturation is also depending on urinary pH, ionic strength, solute concentration in the urine, and complications. Three conditions must coexist for the formation of Struvite calculi.

1. Alkaline pH of urine,
2. The availability of urea or ammonia in the urine
3. The high amount of minerals in the urine.

SIGNS AND SYMPTOMS

Symptoms in kidney stone are not seen until it enters within the kidney or ureters. If it enters the ureters, it may block the flow of urine and cause swelling in the kidney and the spasm of the ureter, which can be very painful. At that point, the following symptoms can be seen:

- Discomfort in the side and back and below the ribs. This discomfort usually occurs only on the side of the renal calculi and does not cross over to the other side.
- Fluctuations in discomfort intensity, with periods of discomfort lasting 20-60 min
- Discomfort waves radiating from the side and back to the lower abdomen and groin
- Bloody, cloudy, or foul-smelling urine
- Discomfort, pain, and inflammation on urination
- Nausea and vomiting

- Persistent urge to urinate
- Fever and chills if an infection is present.
- A feeling of sudden urinates.
- Burning feeling at urination.
- The color of the urine will be dark or red due to blood particles of RBCs. In some cases, the color of the blood is very less that is not seen by naked eyes.
- Feeling of nausea and vomiting.
- Male patients feel pain at the tip of their penis.

Nephrolithiasis that do not cause these expressions may show up on x-rays when the patients seek medical care for other complications, such as blood in the urine or reappearing urinary tract infection.

RISK FACTORS

Dietary factors are key points for promoting or inhibiting the development of kidney stones. Other variables include climate, body weight, genes, and how much of a fluid intake will shape the stone. Following factors that increase the risk of developing kidney stones include:

Table No. 2: Risk factors

Factors: -	Example
Metabolic	Hypercalciuria – High urine calcium
	Hyperoxaluria – High urine oxalate
	Hypocitraturia – Low urine citrate
	Hyperuricosuria – High uric acid
	Low urine volume
Dietary	Low calcium intake
	High intake of animal protein
	High oxalate intake
Infections	Recurrent urinary tract infection
Hereditary	Positive family history
Congenital anatomic defects	Medullary sponge kidney, horseshoe kidney, and ureteropelvic junction obstruction
Environmental	Hot and arid climate. People working outdoors in hot weather have an increased risk of stone formation due to excessive fluid loss from sweating
Systemic disorders	Hyperparathyroidism, diabetes mellitus, hyperuricemia, metabolic syndrome, etc.

DIAGNOSIS

The diagnosis is based on the experience of the case, on clinical assessment, and the laboratory and imaging screening testing required. The history and clinical review established the urologist's hypothesis of urologist's diagnostic testing seeks to support the diagnosis, examine the urinary tract's structure and anatomy and determine possible etiological causes that could be implicated in the development of stones. Imaging and laboratory testing are categorized into screening tests needed for the investigation of urolithiasis. Based on the situation, the psychiatrist will decide which assessments are appropriate.

Imaging screening tests:

- Plain X-ray of kidneys, ureters, and bladder (KUB X-ray): It traces about 80-90% of stones. However, for KUB X-rays, there are stones (such as uric acid stones) that are not visible.

- Ultrasound (U/S) of the urinary tract: It provides information on the presence of obstruction (hydronephrosis) and can trace stones located in the kidney or bladder, but not in the ureter.
- Intravenous Urography or Pyelography: It indicates the exact location of stones and any structural anomalies that may occur which predispose to the formation of stones. It is also beneficial for determining the functionality of the kidneys and the extent of hydronephrosis.
- CT scan without contrast medium: Today this is the screening method of choice used in most urological centers for investigating urolithiasis, as it is diagnostically superior to intravenous urography and provides high-resolution imaging of renal anatomy.

Laboratory tests:

- General urine test (Urinalysis): In the urine, there are normally red blood cells (erythrocytes) and occasionally features of urinary tract infection also occur.
- Biochemical blood analysis: Assessment of blood plasma urea, creatinine, uric acid, and calcium.
- Parathormone: The hormone secreted by the parathyroid glands; in cases with elevated calcium levels, it is calculated and there may be glandular over function that leads to the development of stones.
- 24-hour urine collection: The goal is to determine the physiological status of the patient to detect any possible metabolic anomalies that may be responsible for the formation of stones.
- Stone analysis: After the stone is extracted, it is analyzed to determine the type of stone in specialist laboratories and take the required precautions required to minimize the risk of recurrence and relapse of urolithiasis.

TREATMENT

Small stones

The small stones are usually less than 4mm in size and they do not require much treatment; they get off the body by drinking a precise amount of water. Drinking plenty of water to about 4-5 liters per day helps to get rid of stones throughout the body through urine. The

movement of stones creates pain and the moving pain can be treated with certain pain relievers.

Medical therapy for kidney stones

Usually, doctors prescribe alpha-blockers; they relax the muscles in the ureters, which help to pass the kidney stone more quickly. Diuretics are also useful for increasing the urine flow to pull out the stone.

Large stones

Large stones are usually greater than 8mm in size. Large stones are not easy to remove by drinking plenty of water as they cannot pass out from the body as they get a block in the renal tube. These stones may be harmful to the body because they can damage the kidneys and cause internal bleeding, loss of nephron, or can cause some urinary tract infections. The larger stones cannot pass through the kidneys because they are large in shape and are maybe chances of break down. Hence, this causes bleeding, UTIs, and damage to the kidneys.

Invasive methods include

- **Extracorporeal Shock Wave Lithotripsy (ESWL):** The stone is broken with the use of shock waves. Typically, the patient is well handled and has a 90% success rate. However, there are still some stones that ESWL cannot break. (Figure 2.A)
- **Ureteroscopy and Intracorporeal Lithotripsy:** It is used to detach ureter-located stones. The ureteroscope is placed into the ureter through the urethra until the stone is localized and the parts are extracted. Laser Lithotripsy is the most innovative procedure. (Figure 2.B)
- **Percutaneous Nephrolithotripsy (PNL):** It is used for removing large or dense kidney stones that do not break with extracorporeal lithotripsy. The nephroscope is inserted through the skin into the kidney, localizes the stone, and breaks it up with the use of special ultrasonic or ballistic devices. (Figure 2.C)
- **Open Surgery:** Today it is used only for very few selected cases.

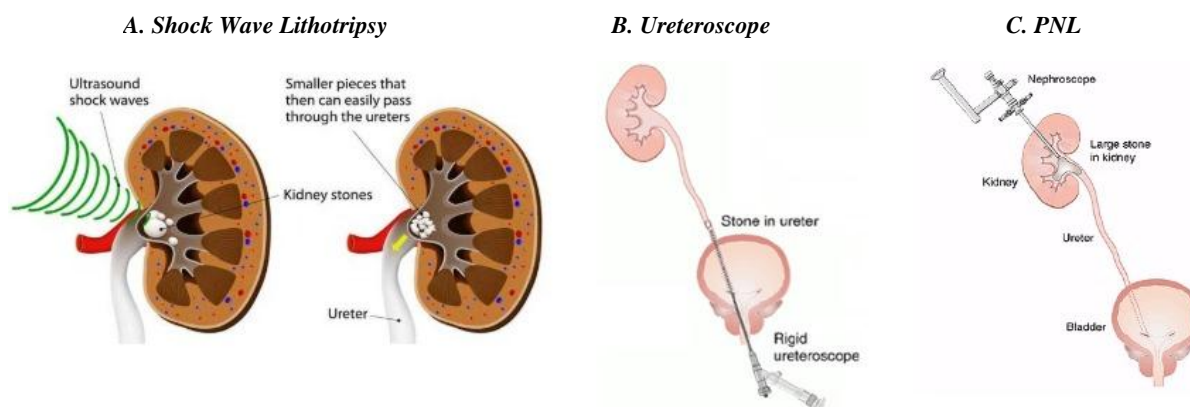


Figure No. 2: Invasive methods

Allopathic medicine for the treatment

It is not enough to change diets and take more fluids to Stop the accumulation of stones in the kidneys. Doctors are required to prescribe the medication to get rid of stones in the body that have developed. The type and size of Stone and urine anomalies can decide the best drug. The drugs that are used for stone removal are provided.

Table No. 3: Treatment through allopathic medicine

Drug: -	Action/Effect: -
Allopurinol	Allopurinol lowers the raised amount of uric acid in the blood and urine.
Corticosteroid	Corticosteroids like prednisone are potent anti-inflammatory drugs and reduce inflammation associated with urinary stones.
Cholestyramine (Questran)	It increases the hepatic LDL receptors.
Cholic acid	It induces bile flow, feedbacks.
Digoxin	Inhibit the Na ⁺ , K ⁺ ATPase.
Etidronate disodium	It prevents hydroxyl apatite Dissolutions
Fluvastatin	Reduction of LDL level. Its competitive Gall stone diseases inhibit
Thiazide diuretics	These drugs help the kidneys to remove excess calcium from the body and prevent the formation of calcium stones.
Vitamin B6 or Pyridoxine	Urinary oxalate is important in the formation of calcium oxalate stones. It inhibits urinary oxalate formation.
Nifedipine	IT is a calcium channel blocker that is used for a cardiovascular conditions like hypertension and angina. It relaxes the smooth muscles of the urinary tract and facilitates the expulsion of the stone.

Herbal treatment

Herbs and herbal remedies are useful for kidney stones. These drugs have developed among people through their awareness of them. Clinically proven effects such as immunomodulation, adoeszptogenic and antimutagenic effect. Overuse of synthetic drugs also results in the higher occurrence of drug adverse reactions have inspired humans to back to the use of natural remedies.

Table No. 4: Herbal remedies for kidney stone

Herbs: -	Action/Effect: -
<i>Aerva lanate</i> (L.) Juss. ex Schult.	Exhibited the reduced activity of oxalate synthesizing enzymes, and diminished the markers of crystal deposition in the kidney.
<i>Adiantum capillus-</i> <i>veneris</i> L.	A lower dose of 127.6 mg/kg b.w. had a significant impact on reducing the elevated level of calcium oxalate crystals in urine than its higher dose.
<i>Agropyron repens</i> (L.) P. Beauv	In folk medicine, its rhizome has been used to treat nephritis, urethritis, and urinary calculi.
<i>Ammannia baccifera</i> L.	The oral administration of ethanolic extract of <i>A. baccifera</i> (2 g/kg/day) was found to be effective in reducing the formation of stones.
<i>Zea mays</i> L.	It is a well-known herbal diuretic, mentioned in almost 93 phytotherapy books from 13 countries.

Homeopathy treatment

Homeopathy is one of the most popular holistic systems of medicine. The aim of homeopathy is not only to treat kidney stone but to address their underlying cause and individual susceptibility.⁵¹list of homeopathy medicine for kidney stone are Argentum nircum, Asparagus, Belladonna, Benzoic acid, Bryophyllum, Calcarea carb, Cantharis, Chimaphila umb, Hydrangea Hydrastis, Nux vomica, Ocimum Can, Tabacum Sarsaparilla, Tabacum.

MANAGEMENT OF REOCCURENCE OF KIDNEY STONE

Calcium oxalate stones: - A reduction in urine oxalate reduces the supersaturation of calcium oxalate. In patients with the common form of nephrolithiasis, avoiding high-dose

vitamin C supplements is the only known strategy that reduces endogenous oxalate production.

Calcium phosphate stones: - There are no current randomized trials to base preventive recommendations for calcium phosphate stone formers, so the interventions are focused on modification of the recognized risk factors. Reduction of dietary phosphate may be beneficial by reducing urine phosphate excretion.

Uric acid stone: - The mainstay of prevention of uric acid stone formation entails increasing urine pH. While acidifying the urine can be challenging, alkalinizing the urine can be readily achieved by increasing the intake of foods rich in alkali and reducing the intake of foods that produce acid can be used to reach the recommended pH goal of 6–7 throughout the day and night.

Struvite stones: - These stones require complete removal by a urologist. The new stone formation can be avoided by the prevention of UTIs.

SUMMARY

A kidney stone is the most common & life-threatening condition. It generally happens with ages. And its cases are increasing worldwide. The most common type of kidney stone is calcium oxalate stone. However, the reason for the formation of the renal stone is still unclear. But, the risk factors like metabolic diseases such as hypertension, type 2 diabetes mellitus, gout, obesity, and high-fat diet, and inadequate nutrition may result in the formation of kidney stones. The reoccurrence of stone is prevented by maintaining a proper diet and high fluid intake. Early diagnosis and early treatment help in minimizing the size of the stone. The various techniques used for the treatment of kidney stones are allopathic, herbal, and homeopathic medication or removal of stones through invasion or surgery. But most people prefer herbal treatment for the removal of stones.

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