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A Comprehensive Review on Kidney Stones, Its Treatment and Recent Advancement

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ABSTRACT: Kidney stones are very common in India and other underdeveloped countries. In wealthy countries, kidney stones afflicted 10% to 12% of the population. The vast majority of people develop kidney stones later in life. The most common sort of stone seen in both men and women is kidney stones. Kidney stones are caused by a variety of factors, one of which is obesity. Kidney stones are caused by calcium oxalate crystals, a high level of uric acid, and a lack of citrate in the body. Foods high in oxalate, such as cucumber, green peppers, and beetroot, are recommended since a minor reduction in urinary oxalate has been associated to a significant reduction in the development of calcium oxalate stones. Spinach, soya bean, chocolate, rhubarb, popcorn, should all be avoided.The kidneys, ureters, and urethra are the main targets of kidney stones. More importantly, kidney stones are a recurrent condition with a lifetime recurrence risk of up to 50% according to calcium oxalate crystals. Calcium oxalate kidney stones are the most common stone seen in India. There is a higher danger of acquiring heart diseases as a result of kidney stone disorders, which are currently being discovered in India and around the world. This overview looks at the history of kidney stones, the different forms, and the medications used to prevent them, as well as future therapeutic directions. Original and review investigations found kidney stones, as well as their diagnosis and therapy.

KEYWORDS: calcium oxalate crystals, uric acid stones, surgical treatment, Recent Advancement

I. NTRODUCTION

The urinary system is made up of two major shaped organs: kidneys, ureters, bladder, and urethra. Below the pairs of ribs in the centre of the back, these bean-shaped kidneys are determined experimentally. Water and waste are extracted from the circulating blood and converted to urine by the kidneys. [1] In the last 20 years, kidney stones have become a global problem, with a large increase in prevalence. According to the National Health and Nutrition Examination Survey, 8.8% of Americans have kidney stones, with males accounting for 10.6% and women for 7.1 percent (2007- 2010). [2] Urolithiasis, commonly known as 'Nephrolithiasis' or kidney stones, is a global disease that has afflicted humans since ancient times.Urolithiasis is a condition in which uroliths/stones obstruct the urinary tract. In the Western world, the annual incidence of Urolithiasis is 0.5 percent, with a lifetime risk of 10-15 percent, however in the Middle East, it is increasing by 20-25 percent. Urolithiasis is a condition marked by the formation of irregular calculi in the urinary tract. [3] In medicine, calculi refers to uroliths, stones, or crystals in the urinary tract. Urolithiasis affects about 0.5 percent of the Western world's population each year. The danger of developing is throughout the rest of one's life.

Approximately 10-15 percent, although it is increasing at a rate of 20-25 percent throughout the Middle East. Urolithiasis is a condition in which the urinary tract forms abnormal calculi. According to science, calculi are

uroliths, stones, or crystals. The deposition of polycrystalline aggregates with particular amounts of crystalloid and organic matrix results in the creation of these calculi/stones. The size and shape of these calculi varies, and they can be found anywhere in the urinary tract, from the kidney to the bladder. [4] Mineral depositions in the pelvis and renal calyces, attached or detached to the renal papillae, are known as stones. The stone is made composed of crystalline and organic components when urine becomes supersaturated with a mineral. Calcium oxalate is a calcium oxalate that forms when calcium phosphate is broken down calcium phosphate foundation known as Randall's plaques, is the most common component of most stones. [5]

1.1 Composition of kidney stone

Urinary stones have been made from phosphate, uric acid, magnesium ammonium phosphate, apatite, and struvite crystals. 5 Calcium-containing stones account for over 75% of all urinary calculi, and they might be crystals of pure calcium oxalate (50%) or calcium phosphate (5%), or a combination of the two (45 percent). Food can change the acidity of urine as well as the concentration of certain compounds in the urine. According to a 24-hour urine sample, any of the following characteristics increases the likelihood of producing a stone: [6]

I. High levels of calcium (hypercalciuria)
II. High levels of oxalate (hyperoxaluria)
III. High levels of uric acid (hyperuricaemia)
IV. Low levels of citrate (hypocitraturia)

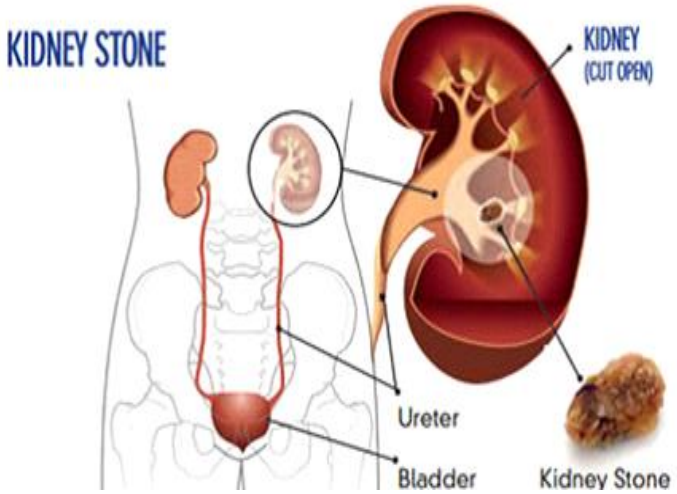

Figure 1 Location of Kidney stone.

1.2 Types of kidney stones

1.2.1 Calcium stones:

Calcium oxalate, alone or in conjunction with calcium phosphate or calcium urate, is the most common cause of calcium stones. Low urine volume, hypocitraturia, and hypercalciuria are all risk factors for calcium stone formation. Calcium stones can be caused by hyperparathyroidism, cancer, sarcoidosis, and an excess of vitamin D. [7], Some rare monogenic causes of kidney stones include X-linked condition and Dent's disease. Calcium phosphate stones are more likely to form if your urine is alkaline.

1.2.2 Uric acid stones:

The primary cause of uric acid stones in patients is a history of gout. [8] A diet heavy in animal protein and purine may increase the chance of developing uric acid stones. [9]

1.2.3 Struvite stones

Struvite is made up of stones made of magnesium ammonium phosphate that grow to fill the collecting system (partial or complete staghorn calculi). This stage is caused by Gram-negative urea-splitting rods like Proteus, Pseudomonas, and Klebsiella species, which cause chronic urinary tract infections. [10]

1.2.4 Cystine stones:

Nephrolithiasis is the most common symptom of cystine stone formation and is caused by improper renal tubule transport, which results in a large volume of cystine excretion in the urine. Cystinuria affects both men and women equally, albeit men are more seriously affected. Stones appear throughout the first to fourth decades of life and are usually numerous, big, and bilateral. There are several observations of characteristic hexagonal crystals in the urine in the diagnosis of cysteine stone.[11]

1.3Causes of Kidney Stones

For some persons, a variety of circumstances contribute to an increased risk of stone formation. The following are some of the factors, according to Kidney Health Australia. [12]

1. Urine with too much calcium, phosphate, oxalate, and uric acid
2. Absence of stone-inhibiting substances in the urine
3. Inadequate hydration
4. Some medications
5. Ongoing urine infection
6. Rare inherited conditions
7. Family history of stone formation

1.4 Signs and symptoms

1. Waves of severe pain.
2. Blood in the urine.
3. Nausea or vomiting
4 .Pain during urination and an urgent need to urinate.[13]

1.5 Treatment:

Kidney stones are categorised according to their size and location. The stone has a 90% chance of passing without surgery if it is less than 4mm in diameter. Only 20% of the time are stones larger than 6mm allowed to pass. Stones tend to get trapped in the thin portions of the ureter. The first place to look is at the ureter-kidney junction. When the blood arteries to the legs cross the ureter midway between the bladder and the ureter, the next position is about halfway between the bladder and the ureter. The portion where the bladder and the ureter meet is the narrowest. Urinary frequency and burning are frequent symptoms of urinary tract stones.

1.6 Risk of factors

I. Dehydration of the body

II. Kidney stones may be inherited from one's parents. Cystinuria is a hereditary condition that raises the chance of cystine stones.

III. A higher protein, fat, sodium, and sugar intake in the diet may raise the risk of kidney stones.

IV. People having kidney infections (especially women) and urinary tract infections (UTIs) can develop more easily struvite stones compare to other diseases

V. Metabolic syndrome developed kidney stones

VI. Obesity may increase risk of kidney stones.[14]

1.7 Surgical Treatment:

1.7.1 Extracorporeal shock wave lithotripsy

Because of its noninvasive nature, low cost, and high efficacy of stone disintegration with fewer problems, ESWL is the first line treatment for renal stones, proximal stones, and midureteral stones.

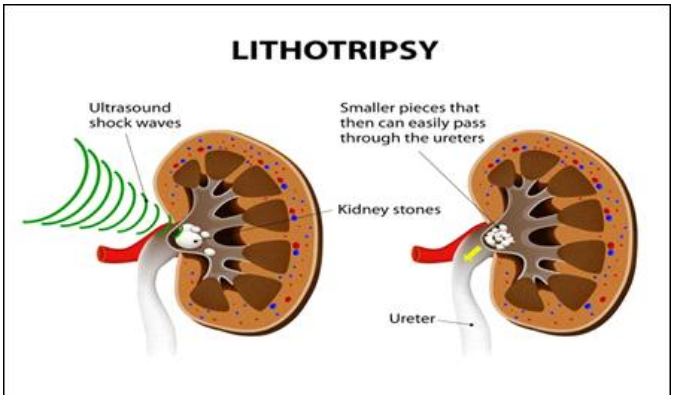

Figure 2 Shock wave lithotripsy.

1.8 Open Surgery

Recent advancements in the field of endourology, such as Open surgery, have resulted in a dramatic reduction in the use of more severe treatment options. [15]

1.8.1 Percutaneous nephrolithotomy PCNL:

Minimally invasive methods have gained widespread acceptance and have nearly completely replaced open surgery for the treatment of all stones more than or equal to 2 cm in diameter.[16]

1.8.2 Calcium stones Treatment:

Lower calcium excretion in the urine has been associated to dietary salt limitation. Patients with hypercalciuria were treated with thiazide diuretics, which boosted blood calcium levels while lowering urine calcium levels and lowering urine calcium levels. It's important in therapy because restricting dietary calcium limits the amount of calcium available to bind oxalate in the intestinal lumen. As a result, more oxalate is absorbed, resulting in increased urinary oxalate excretion. [17]

1.8.3 Treating uric acid stones:

Urine alkalinization is a crucial step in the treatment of uric acid stones. Animal proteins should be consumed in moderation, as this helps to minimise uric acid production. A xanthine oxidase inhibitor is a medication that prevents the formation of uric acid. A reduced purine diet is recommended if the patient's blood uric acid level is high.[18]

1.8.4 Treating cystine stones:

Drinking extra water is the single diet recommendation for cysteine stones. By alkalinizing the urine, cystine solubility can be enhanced. Thiol-containing medicines may be given to patients who are unable or unwilling to comply with increased fluid intake and urine alkalinization. These drugs increase the solubility of cystine. Tiopronin is more well-tolerated than penicillamine, which can cause a rash, fever, serum sickness, epidermolysis, and membranous nephropathy. Captopril is used because its sulfhydryl group produces a thiol-cysteine disulfide bond that is more soluble than cysteine. Its efficacy, on the other hand, remains unknown. A low-animal-protein diet is recommended.

1.8.5 Treating Struvite stones

The best treatment for struvite stones is surgical removal because they are so large. Antibiotic therapy is essential for preventing the progression of stones. Culture stone material can help with direct antibiotic therapy. A low-sodium diet can help prevent the production of struvite stones. [19]

1.8.6 Medical expulsive therapy

MET is an effective treatment for urethral calculi. [20]Alphaadrenoreceptor antagonists (alpha-blockers), calcium channel blockers, and phosphodiesterase-5 (PDE5) inhibitors are thought to diminish ureteral contractions, inhibit peristalsis, and aid in the removal of stones by relaxing the ureteral smooth muscle. [38,39] The adrenergic receptor subtypes alpha1A and alpha1D are more abundantly expressed in the distal ureter. [40] An alpha-adrenergic blocker that is used to treat benign prostatic hypertrophy in men. [41] The thiazide class of medicines is the most commonly prescribed for calcium stone prevention. [21] Allopurinol has been shown to be effective in preventing calcium oxalate stones. [22] Nonthiazide diuretics, such as indapamide, have emerged as an effective calcium stone recurrence prevention method.

1.9 Recent Advancement

1.9.1 Ureteroscopy

Ureteroscopy is a treatment used to remove stones that have been lodged in the ueters or bladder. Ureteroscopy can be used to examine stones in the upper urinary tract. This is a painful process that includes a short wire that links to a camera at the end. A cage is attached to the wire, which is introduced into the urethra and passed into the bladder to remove stones. (Figure 3).[23- 24]

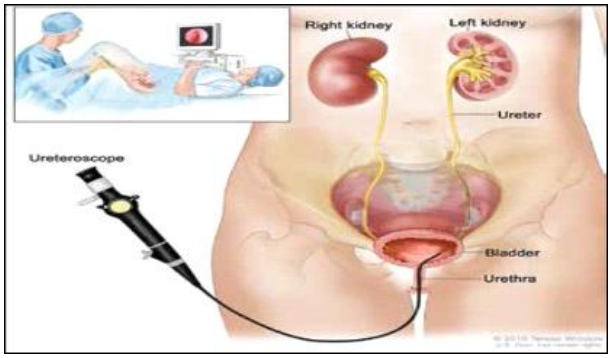

Figure 3 Removal of kidney stones by Ureteroscopy.

1.9.1 Robotics

A modified robotic catheter system for ureter or enoscopy has recently been discovered by researchers. The approach was'stable, easy to manipulate, and ergonomically superior' to traditional ureter or enoscopy, with total fragmentation of tiny stones. [25] Researchers discovered evidence that a natural fruit extract can dissolve calcium oxalate crystals in the kidneys. This discovery could lead to the first breakthrough in calcium oxalate stone treatment in 30 years.

1.10 Percutaneous nephrolithotomy

The doctor uses a nephroscope, a narrow viewing equipment, to detect and remove the kidney stone. The doctor inserts the gadget directly into your kidney through a small cut in your back. If the kidney stones are particularly large, a laser may be used to split them up into tiny pieces. Percutaneous nephrolithotomy is done in a hospital under anaesthesia. You may need to stay in the hospital for several days following the procedure. Following these therapies, your urologist may insert a ureteral stent, a small flexible tube in your urinary stream that aids urine flow or stone passage. Following the removal of the kidney stone, [26 27]

TABLE 1:Classification of urinary stone patients as uncomplicated on the basis of their medical history [28]

Findings	Action
First episode	Cave: History of "frequent kidney pain" in childhood, but unclear origin
Age: adult	
No anatomic abnormalities	Exclusion of, for example, horseshoe kidney and outlet stenosis
Probable correlation with lifestyle	For instance, stone formation at or soon after a time of unusual stress and specific compensation reactions
Negative family history of urolithiasis	Cave: Hints of possibly undiscovered stones in family members through statements such as "There was something, but I can't quite remember..."
Single stone	Assessment with suitable imaging procedures

TABLE 2:Classification of urinary stone patients as high risk [29 30]

Findings	Action
Age; child or adolescent	Consider assessing siblings for risk of lithogenesis
Brushite, uric acid/urate, infectious stones	Bear other accompanying minerals in mind in diagnosis and treatment
Chronic psychovegetative stress	Establish severity, perhaps with aid of validated stress-assessment systems
Single kidney	
Malformation of the urinary tract	
Disorders of gastrointestinal function	E.g., Crohn disease, ulcerative colitis, sprue, chronic pancreatitis, liver cirrhosis, small bowel resection
High recurrence rate	More than three stones in 3 years. Changes in stone type (principal and subsidiary mineral phase) or composition may indicate alterations in metabolic conditions
Hyperparathyroidism (HPT)	Five forms of HPT, primary to quinary
Nephrocalcinosis	Numerous causes, e.g., following renal tubular acidosis, primary hyper - oxaluria, sarcoidosis, HPT, chronic glomerulitis
Positive family history	Consider assessing patient's children for risk of lithogenesis
Primary hyperoxaluria	Two types, autosomal-recessive hereditary disease
Renal tubular acidosis	Test by means of urinary pH curve, blood gas analysis, and ammonium chloride load test
Residual stone fragments	Possibly consider endoscopic means of stone removal, particularly when the

	concrement is of a type that resists disintegration by ESWL, e.g., brushite, cystine, whewellite
Cystine, 2,8-dihydroxyadenine, xanthine stones	Stone formation genetically determined; lifelong metaphylaxis is mandatory

II. CONCLUSION

Urolithiasis is a frequent condition that is growing more common. Surgical treatment comes in a variety of shapes and sizes. Despite tremendous progress in the development of new medicines to treat urinary stones, the discovery of novel therapy targets based on molecular and cellular alterations linked with stone formation will help in the development of better therapies. Furthermore, a better understanding of the urolithiasis processes linked with stone inhibitors or promoters would be critical for stone-removal medications. In the near future, it will be crucial to understand the underlying pathophysiology of urolithiasis.

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