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Review Article

A Review Article On Nephrolithiasis (Kidney Stones)

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ABSTRACT

Kidney stones are a major problem both in India and developing countries. Kidney stones commonly affect his 10-12% of the industrial population. Most people develop kidney stones later in life. Kidney stones are most common in both men and women. Obesity is one of the main risk factors for stone development. The most common causes of kidney stones include calcium oxalate crystals, high levels of uric acid, and low levels of citrate in the body. Small reductions in urinary oxalate levels have been found to be associated with significant reductions in calcium oxalate stone formation. Therefore, it is recommended to avoid foods rich in oxalates such as cucumbers, bell peppers, beets, spinach, soybeans, chocolate, rhubarb, popcorn, and sweet potatoes. Kidney stones primarily affect body parts such as the kidneys, ureters, and urethra. More importantly, kidney stones are a recurrent disease and, because they contain up to 50% calcium oxalate crystals, there is a lifetime risk of recurrence. Calcium oxalate kidney stones are the most commonly reported stones in India. Therefore, there is a high risk of developing heart disease due to kidney stone disease, which is currently being detected in India and other countries. When kidney stones form, the mineral content in the body decreases, reducing the elements necessary for bone formation. If a patient is found to have high levels of lipids in their blood, they may be more prone to forming kidney stones compared to normal people. Patients are encouraged to eat a low-fat diet and get fibre from natural plants and herbal medicines. Combining herbal medicine with allopathic treatment is a great idea to eliminate all complications related to kidney stones.

INTRODUCTION

Renal calculi are one of the most prevalent urologic issues. The frequency of renal calculi is on the rise, with an approximate occurrence rate of 10% to 15% globally [1]. Order monuments can beget pain, blood in the urine, infection, dropped order function, and order failure [2]. Urolithiasis (calculi in the urinary tract) is a prevalent medical issue with an occurrence rate of roughly 2% to 3% in the overall population. It has been approximated that 50% of individuals with prior urinary stones experience a relapse within a decade [3] . The development of kidney stones relies on the excessive concentration

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of salts in the urine and the trapping of crystals in the urinary system [4]. Nephrolithiasis not only results in acute illness for patients experiencing intense pain, but also entails a multitude of medical expenses [5]. Approximately 70-80% of upper urinary tract stones are made of calcium and are therefore expected to be visible on abdominal radiography (also known as KUB). However, factors such as gas in the intestines, calcification outside of the kidneys, and the size of the patient can limit their detection. The accuracy of radiography in detecting kidney stones has been reported to be between 45-85%. While not as accurate as other methods, KUB plays a role in planning SWL, ureteroscopy, and percutaneous nephrolithotomy [6]. The National Health and Nutrition Examination Survey (NHANES) III (1988-1994) stated that there was a 5% occurrence of stone formation among adults in the United States and this represented a 4% rise from the NHANES II (1976-1980). Nephrolithiasis is considered to be a condition of wealth like obesity, high blood pressure, and type 2 diabetes because it is so widespread in affluent countries. Urologic intervention is necessary in as many as 20% of patients with renal colic and over $2 billion is spent on treatment each year. The lifetime occurrence of kidney stones in the United States is 12% among men and 7% among women [7].

Formation of kidney stones:

When the concentration of calcium oxalate (caox) is four times higher than the normal solubility, a crystal begins to form. If the concentration of caox is between seven and eleven times higher than normal solubility, nucleation occurs. In cases of low urine volume, high levels of calcium, and high levels of oxalate, the supersaturation (SS) of caox increases. Citrate in the urine combines with urinary calcium to form a soluble complex. If the urine has a low concentration of citrate, the formation of caox stones is promoted. When the urine pH is above 6.5, there is an increase in the proportion of divalent and trivalent ions, making the formation of calcium phosphate (cap) stones more favourable. The levels of supersaturation of different solutes in the urine determine the specific types of stones that form [8].

Composition of kidney stones:

A renal stone is a group of crystals that come together to form a solid mass in one or both kidneys. They can range in dimensions from a few millimetres to several centimetres. Most stones will exit the body naturally through the urine, but certain cases may necessitate medical intervention for their extraction [9]. Usually, kidney stones do now no longer consist best of a unmarried chemical compound, however there may be a aggregate of numerous compounds. In a unmarried stone, normally 2–three exceptional compounds have been identified, while the maximum not unusual place compound became whewellite. The studied samples have been decided on the idea in their mineralogical composition taking, additionally, the aggregate of compounds took place in adults into account [10].

- High levels of calcium (hypercalciuria)
- High levels of oxalate (hyperoxaluria)
- High levels of uric acid (hyperuricaemia)
- Low levels of citrate (hypocitraturia)

Types of kidney stones and their treatment:

Calcium oxalate stones:

Calcium oxalate stones contain crystalline elements such as calcium oxalate hydrate, calcium oxalate dihydrate, and calcium oxalate trihydrate [11].

Treatment:

The strategy for decreasing calcium oxalate supersaturation caused by hyperoxaluria involves enhancing urine volume and reducing urine oxalate and calcium excretion rates. Administering calcium carbonate or citrate during meals decreases the absorption of oxalate [12].

Cystine calculi:

These calculi have a tendency to develop exclusively in individuals with cystinuria, an inherited disorder that affects 1 in 15,000 adults in the United States and is responsible for only 1% of cases of nephrolithiasis. In cystinuria, nephrolithiasis is the sole clinical manifestation and it occurs due to abnormal transport of cystine in the renal tubules, resulting in significant urinary excretion of cystine [13]. Cystinuria affects both males and females equally, although males experience more severe symptoms. Calculi typically start forming between the ages of 10 and 40 and are often large, numerous, and present on both sides [14].

Treatment:

The management of cystinuria focuses on reducing the level of cystine in the urine to below 250 mg/L by increasing urine production, limiting sodium intake in the diet, and minimizing the consumption of methionine and cystine from animal protein. The ability of cystine to dissolve is improved when the pH of the urine is kept between 7.0 and 7.5. While restricting protein intake may help in achieving this, treatment with potassium citrate or sodium bicarbonate is usually required [15].

Uric acid stones:

Urate acid stones are crystalline constituents of urate acid anhydrous and urate acid dehydrate, typically 5-10% of individuals with kidney stones are impacted by urate acid stone. Urate acid is a metabolic by-product and approximately 25% of patients with this stone also experience gout condition. Primary cause for this form of stone is diminished urine volume, hyperuricosuria and acidic urine pH [16]. A diet rich in animal protein and hindered renal ammoniagenesis are two typical reasons for acidic urine in individuals who form uric acid stones. Hindered ammoniagenesis has been observed in patients with type 2 diabetes, excess weight, and the metabolic syndrome. Gout nearly doubles the likelihood of kidney stones but not necessarily uric acid stones [17].

Treatment:

Elevating the urinary ph and enhancing urinary volume are the most efficient remedies for uric acid stones. Address persistent diarrhea if it is present and suggest a reduced consumption of animal protein. Potassium citrate or sodium bicarbonate can be utilized to attain a pH level of 6.5-7.0 [18].

Struvite stones:

Struvite stones are also referred to as triple phosphate stones, or infection stones. They develop in the presence of upper urinary tract infections with urease-producing bacteria (most commonly Proteus and Klebsiella). Normal urine is not saturated with ammonium phosphate; struvite stone formation occurs only when ammonia production is heightened and the urine ph is raised, which reduces the solubility of phosphate. Bacterial urease is crucial for the formation of struvite stones because it leads to an increase in ammonium, carbonate, and urinary ph simultaneously. In this scenario, phosphate combines with ammonium, magnesium, and carbonate to create a stone made up of magnesium ammonium phosphate (struvite) and calcium carbonate-apatite [19].

Urease breaks down urinary urea into ammonia and carbon dioxide Urea → 2NH3 CO2.

The ammonia generated by this response also combines with water NH3 H2O → NH4 OH [20]. This results in an increased presence of ammonium in an alkaline urine.

Treatment:

The foundation of management for struvite stones is elimination of the infection through the use of antibiotics and the prompt surgical extraction of the bacteria-infected stones. Solely relying on medical treatment with long-term antibiotic therapy is seldom effective and not advised, except in cases where patients are too unwell for surgery or decline stone removal. Acetohydroxamic acid, a urease inhibitor, is the sole medication

authorized for managing struvite nephrolithiasis, although its utilization is restricted due to potential adverse reactions [21].

Table 1: types of stones

Types	Frequency (%)	Sex	Crystals	Radiography
Calcium oxalate/ mix	75	M	Envelope	Round, radiointense, sharply outlined
Calcium phosphate (brushite)	5	F>M	Amorphous: alkaline urine	Small radiointense, sharply outlined
Uric acid	5-15	M=F	Diamond; acid urine	Round/ staghorn, radiolucent, filling defect
Struvite (magnesium ammonium phosphate)	10-20	F	Coffin lid; infection/urea splitter	Staghorn, laminated radiodense
Cystine	1	M=F		Staghorn, radiointense

Symptoms of kidney stones

- Pain in the flank, posterior, and beneath the ribs. This pain typically occurs solely on the side of the kidney stones and does not transfer to the opposite side.
- Variations in pain severity, with episodes of pain enduring 20-60 minutes.
- Pain waves spreading from the flank and posterior to the lower belly and groin.
- Hematuria, turbid, or malodorous urine.
- Pain, discomfort, and inflammation during urination.
- Queasiness and throwing up.
- Constant need to urinate.
- Fever and shivering if an infection existing [22].
- Nausea and vomiting.
- The hue of the urine will appear dark or crimson because of the presence of erythrocytes. Occasionally, the intensity of the blood's colour is so faint that it is imperceptible to the unaided eye [23].

An etiology of disease:

1. Insufficient water consumption.
2. Consumption of water polluted with withered foliage.
3. Consumption of foods that enhance pitta and vata doshas.
4. Blockage in the ejaculation of semen.
5. Consumption of food polluted with pebbles and soil and heightened intake of yogurt and skeletal remains.

Diagnosis of nephrolithiasis:

The renal ultrasonography was carried out and analysed by nephrologists who were not aware of the study's goals and were unaware of the laboratory results. All of the reports were assessed, and the diagnosis of nephrolithiasis was determined by the observation of a bright structure causing acoustic shadowing in the kidney [5].

Blood testing: Blood tests measure elevated levels of calcium or uric acid in the bloodstream. The results of blood tests are useful for monitoring kidney health and may prompt the doctor to investigate other medical conditions [24].

Urine testing: The 24-hour urine collection test can indicate excessive excretion of minerals that form kidney stones or insufficient excretion of substances that prevent stone formation. To conduct this test, the doctor may ask for two urine collections to be performed on consecutive days.

Imaging: Imaging tests can reveal the presence of kidney stones in the urinary tract. Options include

basic abdominal X-rays, which may not detect small kidney stones, as well as high-speed or dual energy computerized tomography (CT) scans that can detect even tiny stones [25].

Diagnosis based on clinical symptoms and laboratory investigation:

Non-invasive treatments Fluid therapy:

Increasing fluid intake prevents the oversaturation of urine. This approach has been scientifically proven to prevent the development of kidney stones [26].

Diuretic therapy:

Enhanced renal output promotes the passage of stones by increasing pressure in the ureter. Diuretic therapy is not recommended for acute ureteric stones [27].

Expulsive therapy:

The goal of expulsive therapy is to facilitate the natural passage of ureteric calculi with the assistance of medications like calcium channel blockers and alpha-1 adrenergic receptor antagonists.

Herbal therapy:

Medicinal plants used in the treatment of urolithiasis act as lithotriptics by reducing the levels of calcium ions in the urine and altering its ionic composition. Some herbs also have diuretic properties, while others inhibit the mineralization of calcium phosphate and calcium oxalate crystals [28].

Surgical therapy:

Extracorporeal shockwave lithotripsy (ESWL) can be employed to break up stones in any part of the urinary tract, but it is primarily used for kidney and upper ureter stones. Ureteroscopy with laser lithotripsy: This procedure can be used to manage stones endoscopically and is the preferred option for ureteral stones, particularly those in the lower ureter. For larger stones (greater than 2 cm) in the renal pelvis, percutaneous nephrolithotomy may be performed [29].

Dietary Interventions:

Table 2. Dietary factors and potential stone risk. [30]

Dietary Factors	Modification	Potential Stone Risk
Fluid intake	Reduction	Increased urine saturation
Sodium intake	Increase	Increased urine calcium and reduced citrate excretion
Calcium intake	Reduction	Increased urinary oxalate excretion
Meat intake	Increase	Low pH of urine, increased urine calcium and reduced citrate excretion
Fruits intake	Reduction	Low pH of urine, and decrease citrate excretion
Diet content of oxalate foods	Increase	Increased urinary oxalate excretion

Extended ingestion of oxalate wealthy meals does bring about extended urinary oxalate excretion, the stability is likewise stimulated via way of means of nutritional calcium intake [31]. Epidemiological proof helps the affiliation among protein consumption and kidney stone risk. Dietary protein limit by myself also can have a positive impact on metabolic threat elements for nephrolithiasis [32]. Diet bureaucracy a crucial aspect withinside the universal clinical method for kidney disorder and performs an essential function in figuring out the composition and useful pastime of the human intestine microbiota, with implications for uraemic toxin production. Moreover, diet-primarily based totally strategies inclusive of making sure good enough consumption of fluid and nutritional calcium, even as heading off excessive intakes of sodium and animal protein are important nonpharmacological prevention techniques for kidney stone disorder

[33]. A kind of nutritional factors, which include fluid intake, nutritional protein, carbohydrates, oxalate, calcium, and sodium chloride can modulate urinary threat profile and make contributions to the threat of kidney stone formation [34]. Animal protein has a better content material of sulphur and generates a better acid load as compared with vegetable protein and has been related to a multiplied occurrence of stone formation, as a minimum in men [35]. Pharmacotherapy is indicated to lessen stone recurrence whilst nutritional measures fail or are beside the point in sufferers with precise metabolic backgrounds, or if the continual kidney sickness and/or metabolic bone sickness dangers are considerable, or in sure corporations of people (for example, flying airline personnel) and in the ones who've excessive urine metabolic abnormalities [36].

TABLE 3. Dietary and medical therapies for kidney stone condition [37]

Abnormality	Diet	Medications
General guidelines	Fluids, limit sodium, citrates	None
Hypercalciuria	Sodium restriction	Thiazide, fish oil
Hypocitraturia	Lemon, lime, melon, oranges	Potassium citrate
Hyperuricosuria	Protein moderation	Allopurinol
Hypernatriuria	Sodium limit 1,500 mg/d	None
Hyperoxaluria	Limit spinach, nuts, berries	Pyridoxine (vitamin B-6)
Low pH	Increase fruits and vegetable	Potassium citrate

Methods:

Ureteroscopes:

The rate of technological advancements has also been very advantageous for ureteroscopes' design and functionality, leading to modern scopes with distinctive characteristics, and distinctions with older technology scopes. Transitioning from fiberoptic to digital systems allowed surgeons to better visualize anatomy, as the "honeycomb" appearance disappeared.25 Sensors of digital scopes are less susceptible to image flickering caused by laser energy-induced shockwaves, thus providing a clear view.6,26 The main disadvantage of digital, "chip on tip" systems is the expense and the fact that sensors are currently produced at specific sizes, which hampers further downsizing of digital scopes [38]. No additional progress was achieved in ureteroscopy until the introduction of fiberoptic technology. The utilization of fiberoptics enabled the reduction in the size of endoscopes and facilitated the creation of ureteroscopes that can be steered and deflected [39]. The sufferers who had kidney stones smaller than cm and have been deliberate to go through surgical treatment have been randomly allotted into 2 companies prospectively. RIRS turned into executed withinside the RIRS institution the usage of a 7.5-F fiberoptic bendy ureterorenoscope at the same time as mini-PNL institution turned into dilated as much as 16.5F and mini-PNL turned into executed with 12F nephroscopy [40].

Extracorporeal shock wave lithotripsy:

The initial human therapy of a stone using ESWL occurred on February 20, 1980, conducted by Dr. Chaussy utilizing an HM1 lithotripter manufactured by the German aerospace company Dornier (Lindau, Germany). In 1984, the first lithotripter available for purchase (HM3) was introduced [41].

Artificial Intelligence, 3D Technology and Virtual Reality:

Virtual reality (VR) surgical training thrived as robotic systems became the primary method for treating cancer patients in the past ten years. VR systems establish an authentic three-dimensional (3D) virtual setting, generated through anatomical

expertise and actual images, providing the user with a highly accurate perspective. Users can virtually engage and carry out exercises or stages of a particular procedure [42].

Technique of PCNL:

Numerous methods have been outlined for percutaneous nephrolithotomy (PCNL), such as placing the patient either face down, face up, or a combination of the two. When patients are positioned face down for puncture, the optimal approach is one in which the needle enters a rear calyx at the fornix, passing through the least amount of kidney tissue and reducing the risk of injury to larger blood vessels in the kidney. In contrast, directly puncturing the front calyx will pass through more kidney tissue and make it challenging to access the collecting system without excessive angling of the puncture tract, leading to increased bleeding [43].

Laser and fiber:

The arrival of the Holmium: yttrium-aluminium-garnet (Ho: YAG) laser transformed the endoscopic treatment of stones over 15 years ago and is presently the preferred method according to the European Association of Urology (EAU) Guidelines [44]. Stone fragmentation is primarily accomplished through a photothermal occurrence, where power is conveyed to water molecules located in crevices and openings of stones, resulting in their breakdown. Thulium fibre laser (TFL) is a more recent laser platform with advantageous physical characteristics in contrast to Ho: YAG. TFL functions at a wavelength of 1940 nm, which is in close proximity to the water absorption peak (1950nm), as opposed to the 2100 nm of Ho: YAG. [45].

Intrarenal Pressure (IRP) and Suction Use During Endourological Procedures:

The use of irrigation fluid is pivotal for optimal visualization during endourological procedures. Research has shown that the normal range for intrarenal pressure (IRP) is between7.5 and14.7 cmh20. However, with osmotic diuresis, this pressure can increase to as much as 25 cmh20. During endourological procedures, the IRP can further escalate, leading to various types of pyelorenal backflow, such as pyelovenous, pyelolymphatic, pyelotubular, and pyelointerstitial backflow. The primary concern associated with this physiological phenomenon is the heightened risk of infection and tissue damage. To address these risks, suction is commonly employed. Its purpose is to ensure clear visualization and minimize intrarenal pressure [46].

Robotic Ureteroscopy (robours):

Implementation of automated systems in the field of urologic cancer treatment has resulted in enhanced clinical results. Desai and colleagues initially documented the application of a robotic system for URS in pig models. They proposed enhanced user comfort when utilizing the Sensei robot, as indicated by surgeons' evaluations on a visual analogue scale regarding the stability (10/10) of the instruments, the ability to reproduce access (10/10), and the automatic retraction feature [47].

Risk factors:

In general, nephrolithiasis often occurs alongside a metabolic abnormality, which can include conditions like excessive calcium in the urine (hypercalciuria), excessive oxalate in the urine (hyperoxaluria), low levels of citrate in the urine (hypocitraturia), cystinuria, and high levels of uric acid in the urine (hyperuricosuria). Among these, hypercalciuria and hypocitraturia are the most common. However, it is important to be aware of certain disorders like cystic fibrosis (CF), spina bifida, and inflammatory bowel disease, as they can increase the risk of stone recurrence or the development of specific types of stones, such as oxalosis or Primary Hyperoxaluria (PH). This disorder has two types, PH-1 and PH-2. Tubular disorders like cystinuria also increase the risk of stone formation and account for 3% of all kidney

stones. Additionally, systemic diseases such as CF and inflammatory bowel diseases (IBD) can contribute to stone formation [48].

Dietary factors are key elements in either promoting or inhibiting the formation of kidney stones. The stones can be formed due to other factors such as the environment, body mass, genetics, and fluid intake levels [49]. The following are factors that can increase the risk of promoting kidney stones:

- Dehydration of the body
- Kidney stones may be the result of genetic factors. Cystinuria is a genetic disorder that increases the risk of developing cystine stones.
- Consuming higher amounts of proteins, fats, sodium, and sugar in the diet may elevate the risk of kidney stones.
- People who have kidney infections (particularly women) and urinary tract infections (utis) are more prone to developing struvite stones compared to other conditions.
- Kidney stones can be developed as a result of metabolic syndrome.
- Obesity can potentially increase the risk of kidney stones. [50]

CONCLUSION

Renal calculus is one of the most prevalent issues in emerging nations and the rest of the globe that impacts the urinary system. Certain medical conditions heighten the susceptibility to kidney stone complications, including a diet rich in fats, insufficient nourishment, consumption of food with oxalate crystals, a diet high in proteins, and postoperative abnormalities. Kidney stones are common and reoccur frequently. Citrate is the most prevalent suppressant of crystal development and urinary pH holds great significance in the prevention and treatment of various stone types. The objective of the treatment is to maintain kidney function and avert disease recurrence. By integrating dietary and medicinal approaches to stone prevention, one can considerably reduce the likelihood of stone reappearance and enhance overall well-being. The primary advantage of PCNL has been reduced hospitalization durations, enhanced patient comfort, and quicker resumption of normal activities in comparison to previous methods of open stone surgery. Point-of-care ultrasound has moderate precision in diagnosing nephrolithiasis.

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