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OVERVIEW OF RENAL STONES ETIOLOGY, MANAGEMENT, AND PATIENT RECOMMENDATIONS

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Abstract:

Background: *Renal stones can form in different parts of the urinary system, including the kidneys, ureters, bladder, and urethra. The stones are typically composed of minerals and salts that have crystallized and fused together. Renal stone is often associated with factors such as an imbalance in the substances that make up urine, leading to the precipitation and aggregation of minerals. The stones can vary in size, and their presence in the urinary tract can cause symptoms ranging from mild discomfort to severe pain, depending on the location and size of the stones.*

Objective: *This review will review the most recent medical literature on renal stone etiology, management, and recommendations.*

Methods: *Comprehensive research on the renal stone etiology, management, and recommendations. PUBMED and Google Scholar search engines were the databases used for the search process, and articles were collected from 2000 to 2023. The term used in the search were: renal stone, etiology, pathophysiology, management, prevention.*

Conclusion: *Renal stone, or urolithiasis, involves the formation of stones in the urinary tract, posing a common health issue with multifactorial causes. Mechanisms include a urine biochemical imbalance, leading to supersaturation, nucleation, and crystal aggregation. Presentations range from asymptomatic to painful symptoms. Surgical management prevails, but the rising prevalence poses health and economic challenges. Stone types like calcium oxalate, calcium phosphate, uric acid, struvite, and cystine have distinct etiologies involving metabolic syndrome, genetic factors, and various medical conditions. Diagnosis integrates clinical evaluation and imaging, primarily non-contrast CT scans. Treatments include NSAIDs, surgical interventions, and homeopathic options. Prevention emphasizes lifestyle changes, dietary modifications, and medication use.*

Keywords: *renal stone, etiology, pathophysiology, management, prevention.*

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INTRODUCTION:

Renal stone, also known as urolithiasis or nephrolithiasis, is a condition characterized by the formation of stones in the kidney, ureter, or bladder (Figure1) [1]. It is a common urinary tract disease with a multifactorial etiology [2]. The exact mechanisms underlying the formation and development of renal stones involve various mechanisms and are believed to involve a biochemical imbalance in urine between stone-forming inhibitors and promoters; kidney stone formation begins with increased urinary supersaturation of lithiasis promoters in the urine, followed by nucleation and aggregation that lead to intrarenal crystal precipitation [3-5]. The renal stone presentation may vary from asymptomatic, which is detected radiologically by the incident when requested for another reason, or with symptoms such as loin or abdominal pain, visible or non-visible hematuria, and eventually the passage of a stone [2,6]. The clinical manifestations of renal stones include unilateral loin region pain, nausea, vomiting, burning micturition, hematuria, dysuria, fever, recurrent urinary tract infections (UTIs), urinary retention, diarrhea, and failure to thrive. Renal and ureteral colics are the most common presenting symptoms, often associated with nausea, vomiting, macroscopic, microscopic hematuria, and in some cases, patients may present with sepsis as the first manifestation of an acutely obstructing kidney stone [7]. Clinical management of renal stones is largely surgical, but the increasing prevalence of the disease is becoming a significant health and economic burden [2]. Various treatment approaches, including pharmacotherapy and herbal formulations, have been explored to manage renal stones. Homeopathic medicine has also shown potential in the non-surgical expulsion of renal calculi[2].

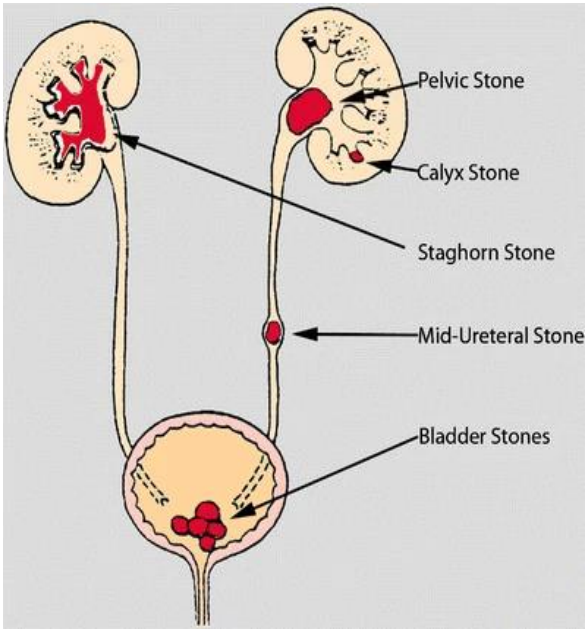

Figure [1]: The type of renal stone according to its location.

Etiology of Renal Stone:

Renal stones can be classified into several types based on their composition. The most common renal stones types include Calcium Oxalate, Calcium Phosphate, Uric Acid, Struvite, and Cystine Stones (Figure 2). Calcium oxalate stones are the most common type of stones, forming when there is a supersaturation of oxalates and calcium in the urine, leading to crystallization [5,8]. The pathophysiology of calcium oxalate stones involves several factors. One theory suggests a common origin between urinary stones and cardiovascular diseases, as they share similar vascular

pathophysiology [8]. Another theory proposes that metabolic syndrome, The presence of MetS components such as obesity, hypertension, dyslipidemia, and insulin resistance, increases the risk of both urinary stones and cardiovascular diseases independently[5]. Underlying medical conditions contribute to the development of calcium Oxalate stones, such as hyperparathyroidism, which causes excessive parathyroid hormone (PTH) production, leading to increased calcium levels in the blood and eventually forming calcium oxalate stones in the urinary tract [9]. Moreover, hyperoxaluria, oxidative stress, and low-grade inflammation are found to have a higher risk of calcium-oxalate stones in diabetic patients, especially men [3]. Furthermore, Slc26a6 deficiency in hypertensive and obese patients can lead to low urinary citrate and calcium oxalate stone formation, which is associated with elevated succinate levels besides Reactive oxygen species (ROS) and oxidative stress [10,11]. These conditions promote hypercalciuria, hyperoxaluria, and hypocitraturia and have been identified as risk factors for stone recurrence[12]. Additionally, Genetic factors such as Klotho gene polymorphisms, diacylglycerol kinase eta (DGKH), solute-linked carrier 4 (SLC4), and SLC26 genes have been implicated in the molecular mechanism of urolithiasis [13-15].

Calcium phosphate stones, such as calcium oxalate and calcium phosphate, are the most common type of stones found in patients with stone formation. These stones can occur due to underlying medical conditions such as hyperparathyroidism, diabetes, hypertension, obesity, and conditions that promote hypercalciuria, hyperoxaluria, and hypocitraturia [16]. The pathophysiology of calcium phosphate stones involves the formation of calciprotein particles (CPP), which are colloidal mineral-protein complexes composed of solid-phase calcium phosphate and serum protein fetuin-A [16,17]. CPP formation is considered a defense mechanism against the unwanted growth of calcium phosphate crystals in the blood and urine [18,19]. However, once transformed into high-density CPP containing crystalline calcium phosphate, they become cytotoxic and inflammogenic, leading to cell death in renal tubular cells, calcification in vascular smooth muscle cells, and immune responses in macrophages. CPP potentially behaves like a pathogen, causing renal tubular damage, chronic inflammation, and vascular calcification.

The pathophysiology of uric acid stones has not been fully elucidated; nevertheless, multiple studies have shown several factors involved. in one hand supersaturation of urine with uric acid is the major mechanism responsible for uric acid nephrolithiasis[4]. In addition, impaired renal ammoniagenesis and Administration of the insulin sensitizer pioglitazone cause excessive net acid excretion and reduced urinary buffering, resulting in uric acid stone formation [4,20]. Uric acid stones in particular, are more common in patients with type 2 diabetes and obesity.

Struvite stones comprise magnesium ammonium phosphate and are associated with urinary tract infections, which lead to pathological biomineralization in the urinary system as a result of the presence of bacteria that play a major role in the specific morphogenesis of struvite stones (urease-producing bacteria), controlling the nucleation, crystalline phases, and shape of the growing crystal [20,21]. Struvite stones is more common in females than in males.

Cystine stones are formed due to a defective amino acid transporter in the proximal renal tubules and the epithelial cell lining of the small intestine, affe cting the transport of cystine and other dibasic amino acids, leading to its precipitation, and formation of cystine stones due to genetic defects responsible for cystine stones are located in the SLC3A1 and SLC7A9 genes, which encode the cystine transporter [20,22].

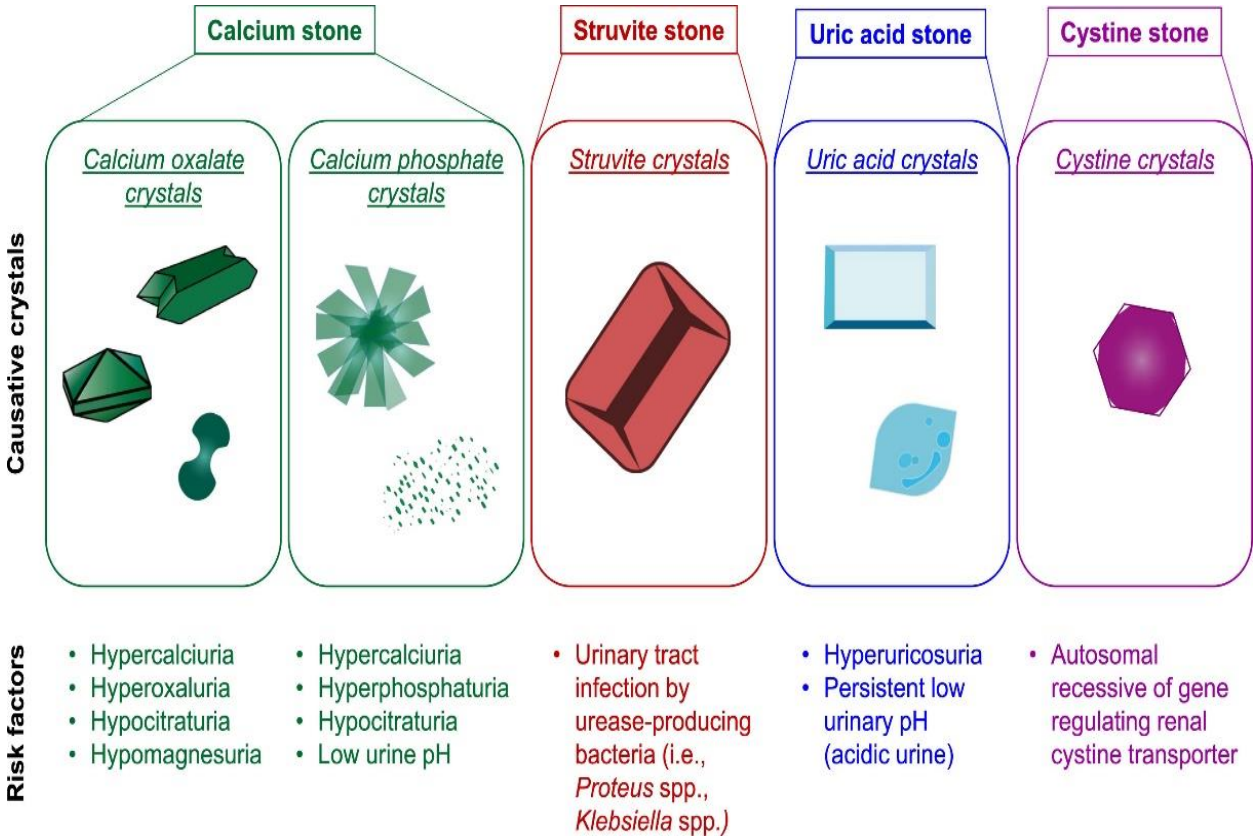

FIGURE [2]: The Risk Factors Related to Each Types of kidney stones.[20]

Diagnosis of Renal stone:

Diagnosing renal stones involves a combination of clinical evaluation and imaging techniques. The recommended diagnostic approach starts with careful history-taking, especially in cases of recurrent attacks of renal colic and stone disease. Investigation for the diagnosis of renal stone includes urine and stone analysis of 24-hour urine collection [23]. Methods such as IR spectroscopy, X-ray diffraction, and optical microscopy are used to investigate the bulk composition of kidney stones[23].

Radiological imaging, including non-contrast CT scans, x-rays, and magnetic resonance urography (MRU), plays a central role in diagnosing renal stones. Non-contrast CT scans have high sensitivity and specificity rates, making them a useful tool for evaluating patients with radio-opaque kidney stones and detecting radiolucent stones and renal pathologies that may be missed with plain radiographs[24]. X-ray-based imaging modalities, such as plain films, have low sensitivity and specificity for detecting renal stones, but they were commonly used in the past. However, the advent of helical CT has largely replaced the need for intravenous urograms (IVUs) and iodine-containing organic compounds for radiological detection [24]. MRU techniques have also advanced and can provide anatomic and functional information on renal perfusion, excretion, and drainage, making them applicable in the diagnosis of urinary tract diseases, including renal stones [25]. Therefore, CT scans, MRU, and to a lesser extent, x-rays, are the main modalities used for the diagnosis of renal stones (Figure3).

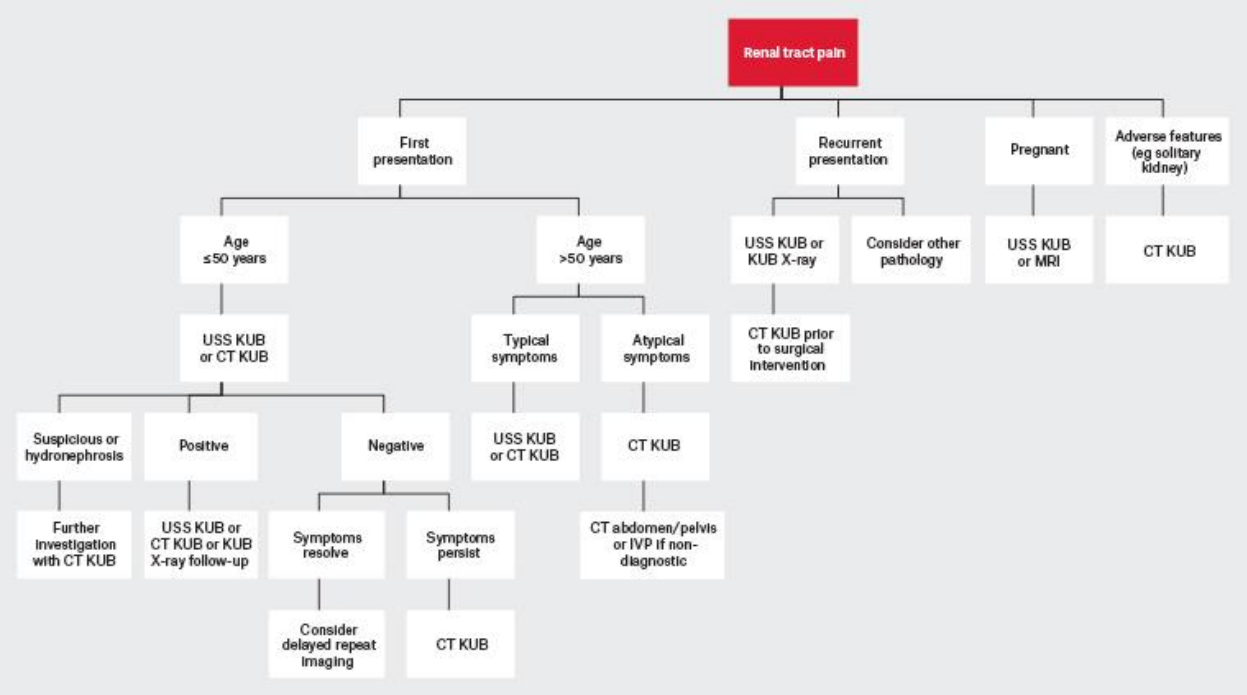

Figure [3]: Diagnostic imaging pathway of renal tract pain [26]

CT: computed tomography; IVP: intravenous pyelogram; KUB: kidneys, ureters and bladder; MRI: magnetic resonance imaging; USS: ultrasonography

Treatment of Renal stone:

Treatment options for renal stone include medical treatment, surgical intervention, and homoeopathic constitutional medicine. Nonsteroidal anti-inflammatory drugs (NSAIDs) are recommended for pain relief in patients with renal colic [2,27]. Alpha-, particularly tamsulosin, can be beneficial for distal ureteral stones larger than 5 mm in size [28]. Surgical intervention is a conventional management approach, but it may not provide a permanent solution [27,29]. Homoeopathic constitutional medicine, such as Nux vomica, treats the patient as a whole and aims to prevent recurrence of symptoms [30].

How to prevent renal stone:

To prevent occurrence of renal stones, several strategies can be employed. These include increasing fluid intake, maintaining a normal body mass index, avoiding dehydration, and making dietary modifications besides lifestyle and habit modifications such as avoiding cigarette smoking and fluid compensation for working in high-temperature environments are also important [20]. Dietary management plays a crucial role, including sufficient calcium intake (1000-1200 mg/day), limiting sodium intake (2-3 g/day of sodium chloride), avoiding oxalate-rich foods, and considering lime powder supplementation [20,31]. Medications such as thiazides, alkaline citrate, and other alkalinizing agents may also be used for stone prevention [20,32]. Additionally, compounds like statins and angiotensin-converting enzyme inhibitors have shown potential in reducing calcium oxalate nephrolithiasis [33].

CONCLUSION:

Renal stone, or urolithiasis, involves the formation of stones in the urinary tract, posing a common health issue with multifactorial causes. Mechanisms include a urine biochemical imbalance, leading to supersaturation, nucleation, and crystal aggregation. Presentations range from asymptomatic to painful symptoms. Surgical management prevails, but the rising prevalence poses health and economic challenges. Stone types like calcium oxalate, calcium phosphate, uric acid, struvite, and cystine have distinct etiologies involving metabolic syndrome, genetic factors, and various medical conditions. Diagnosis integrates clinical evaluation and imaging, primarily non-contrast CT scans. Treatments include NSAIDs, surgical interventions, and homeopathic options. Prevention emphasizes lifestyle changes, dietary modifications, and medication use.

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