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Polyherbal Formulation for Kidney Stones (Urolithiasis): A Comprehensive Review

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Abstract: *Urolithiasis, or kidney stone disease, is a common urinary tract disorder caused by the formation of crystalline stones due to urine supersaturation, crystallization, crystal aggregation, and retention within the urinary tract. Factors such as dehydration, metabolic disorders, dietary habits, obesity, and urinary tract infections contribute significantly to stone formation and recurrence. Kidney stones are mainly classified as calcium oxalate, calcium phosphate, uric acid, struvite, and cystine stones, with calcium oxalate stones being the most prevalent. Common symptoms include severe flank pain, hematuria, nausea, vomiting, and urinary obstruction. Conventional treatments such as ESWL, ureteroscopy, and surgical procedures are effective but may cause recurrence, adverse effects, and high treatment costs. Traditional herbal and polyherbal formulations used in Ayurveda and other traditional systems offer safer and cost-effective alternatives by providing diuretic, lithotriptic, anti-inflammatory, antioxidant, and nephroprotective effects. Medicinal plants such as Punarnava, Pashanbheda, Gokshura, and Varuna play an important role in the prevention and management of kidney stones.*

Keywords: Urolithiasis, Kidney Stones, Polyherbal Formulation, Nephroprotective Activity, Pashanbheda, Gokshura

I. INTRODUCTION

Urolithiasis is the process of a urine stone developing or showing up anywhere along the renal system. It is a chronic health issue that has been around since the dawn of humanity. Ayurveda, Traditional Chinese Medicine (TCM), Siddha, and Unani are only a few of the ancient literature of traditional medicine that contain information on the symptoms, indicators, and treatment methods of urinary stone illnesses. One of the eight most troublesome disorders according to Ayurveda is urolithiasis. Urinary stone treatment in Ayurveda includes herbal formulae, alkaline drinks, and surgical methods. While,TCM advice using a combination of acupuncture, mexibustion, and multi-herbal medications to treat urinary stones. Herbal treatments are still used today to treat and cure urinary stone illnesses among these medicines.

Urinary stones (calculi) are the solid crystalline masses that can occur anywhere in the renal tract and the process of formation of urinary stone or appearance of stone anywhere in the urinary tract is termed as urolithiasis. Urinary stones typically develop when urine loses its normal stone-forming inhibitors or when urine becomes salt-saturated. Numerous environmental and nutritional factors, such as low urine volume and diets high in animal protein, might affect urolithiasis. Additionally, stone formation may be influenced by metabolic changes (such as hypercalciuria and hyperuricosuria) and a lack of stone-inhibiting nutrients (such as citrate, magnesium, and glycosaminoglycans [GAG]).[1] Urolithiasis can be difficult to prevent since it frequently has no apparent symptoms and can go unrecognised until it is quite advanced if recurrence history is not known. Small urinary stones can be effortlessly removed by urine. For stones with a diameter of 5 mm or less and 10 mm or more, the reported spontaneous transit rates are 68 and 47%, respectively. [2]

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Numerous ancient medical literatures from the "Ayurveda,""Chinese" and "Greek traditional medicine" provide descriptions of the symptoms, warning indications, and treatment of urinary stones. Urinary stone disease symptoms frequently include back or lower abdominal pain, blood in the urine, and pain during urinating. [3]Along with the discomfort, other symptoms include nausea and vomiting. When a person has a urinary stone, they may experience waves of discomfort that start in the abdomen, frequently spread to the groin, testicles, or vulva, and then go away in 20 to 60 minutes. Renal colic is the name for this distinct pain.

Dietary modifications or stone expulsive therapy are ineffective in the majority of urinary stone patients because the stones are either too big or become lodged in the urinary tract. Patients in these situations need to be treated using modern interventional techniques. However, the majority of these interventional techniques are difficult to assess and nearly never appropriate for patients with a high prevalence of recurrent urinary stones. As an alternative, it has been discovered that traditional herbal remedies are efficient, accessible, and affordable. Despite their vast historical records of efficacy and use, widespread adoption of these herbal medications remains a challenge. This could be the result of insufficient support from scientific studies.

EPIDEMIOLOGY OF UROLITHIASIS

Urolithiasis, commonly known as kidney stone disease, is one of the most prevalent disorders of the urinary system. Its prevalence varies across different geographical regions and climatic conditions. Globally, the prevalence of kidney stones ranges from 5–15%, and the incidence is steadily increasing due to changes in lifestyle and dietary habits.[4]The disease is more commonly observed in males than females, with the highest incidence occurring between 20–50 years of age. Tropical and subtropical regions show a higher prevalence of kidney stones because high temperatures and dehydration increase urine concentration and promote stone formation.[5] India is considered a part of the "Stone Belt," particularly the northern and western regions, where kidney stone cases are highly prevalent.

Several intrinsic factors contribute to the development of urolithiasis. These include genetic predisposition, hypercalciuria, hyperoxaluria, hyperuricosuria, and various metabolic disorders that increase the concentration of stone-forming substances in urine. Such conditions enhance the risk of crystal formation and stone development in the urinary tract.[6]Extrinsic factors also play an important role in kidney stone formation. Low fluid intake, excessive salt consumption, high animal protein intake, sedentary lifestyle, and prolonged exposure to hot climatic conditions increase urine supersaturation and facilitate crystal aggregation. Together, these factors contribute significantly to the development and recurrence of urolithiasis.[7]

TYPES OF KIDNEY STONE

Kidney stones are classified based on their chemical composition, and each type differs in its cause, prevalence, and clinical characteristics. The major types of kidney stones include calcium oxalate stones, calcium phosphate stones, uric acid stones, struvite stones, and cystine stones. Understanding the different types of stones is important for proper diagnosis, prevention, and treatment of urolithiasis.

Calcium Oxalate Stones

Calcium oxalate stones are the most common type of kidney stones and account for approximately 70–80% of all cases. These stones are formed when calcium combines with oxalate in urine. They are mainly associated with hyperoxaluria, hypercalciuria, dehydration, and oxidative stress. Excessive consumption of oxalate-rich foods such as spinach, tea, nuts, chocolate, and tomatoes may increase the risk of calcium oxalate stone formation. Reduced water intake and low urinary citrate levels also contribute to their development. These stones are hard, highly crystalline, and may cause severe pain, hematuria, and urinary obstruction.[8]

Calcium Phosphate Stones

Calcium phosphate stones constitute about 5–10% of kidney stone cases. These stones are generally associated with alkaline urine, metabolic abnormalities, renal tubular acidosis, and hyperparathyroidism. They are more commonly observed in individuals with disturbances in calcium metabolism. Calcium phosphate stones often occur along with

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calcium oxalate stones and may grow rapidly if left untreated. They can cause recurrent urinary tract infections and kidney damage in severe cases.[9]

Uric Acid Stones

Uric acid stones account for nearly 5–10% of kidney stone cases and are formed due to excessive uric acid concentration in urine and acidic urinary pH. Conditions such as gout, obesity, diabetes mellitus, and high intake of purine-rich foods including red meat and seafood increase the risk of uric acid stone formation. Unlike calcium stones, uric acid stones are radiolucent and may not be visible on plain X-ray examination. Adequate hydration and urinary alkalization are important in preventing these stones.[10]

Struvite Stones

Struvite stones are composed of magnesium ammonium phosphate and represent about 10–15% of kidney stone cases. These stones are commonly associated with urinary tract infections caused by urease-producing bacteria such as *Proteus*, *Klebsiella*, and *Pseudomonas*. The bacterial enzyme urease breaks down urea into ammonia, resulting in alkaline urine and formation of struvite crystals. These stones can grow rapidly and form large staghorn calculi that occupy a major portion of the kidney. Struvite stones are more common in females due to the higher incidence of urinary tract infections.[11]

Cystine Stones

Cystine stones are rare and occur due to a hereditary metabolic disorder known as cystinuria. In this condition, excessive amounts of cystine are excreted in urine because of defective renal tubular reabsorption of amino acids. Cystine has low solubility in acidic urine, leading to crystal and stone formation. These stones usually develop at a younger age and tend to recur frequently. Cystine stones are relatively hard and difficult to treat, often requiring long-term management and preventive therapy.[12]

FACTORS RESPONSIBLE FOR FORMATION OF URINARY STONE

For many years, urolithiasis has been a serious health issue. We still have a limited grasp of the basic processes that lead to the development of urinary stones. It is crucial to have a fundamental understanding of how urinary stones form in order to manage patients effectively, which will lower urolithiasis-related morbidity and medical expenses. It has traditionally been believed that urine supersaturation and the consequent production of crystalline minerals cause the development of urinary stones. However, stones may not always form as a result of spontaneous stone salt accumulation in urine. The multidimensional process of urolithiasis comprises crystal nucleation, aggregation, retention of crystals by the urothelium, urine saturation, urine supersaturation, and the continual growth of the stone on the retained crystals.[13]

It has been discovered that dietary behaviours, particularly those that cause metabolic syndrome or inborn abnormalities are to blame for urine saturation or supersaturation.[14]Numerous epidemiologic and metabolic studies have suggested that diet increases the incidence of urinary stones, and it has been demonstrated that diet affects the composition of urine. The main dietary risk factors are an increase in protein intake, an increase in salt or oxalate intake, and a decrease in calcium intake.[15]Excessive consumption of animal proteins in the diet and a problem with renal ammoniagenesis and/or excretion that impairs buffering and intensifies the acidic urine brought on by an increase in acid excretion. Additionally, it has been discovered that fructose consumption is independently linked to a higher risk of developing urinary stones. [16]Patients with nephrolithiasis who have type II diabetes, obesity, or the metabolic syndrome are more likely to develop uric acid stones.

MECHANISMOF UROLITHIASIS:CRYSTALLIZATIONANDRETENTION OF STONES

Only when,the small stone fragments are maintained in the urinary tract and develop into clinically significant stones does urolithiasis become sick.[17] The three main processes involved in the production of urinary stones are oversaturation of the urine, crystallisation, and retention of the stone within the urinary system.

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Supersaturation of Urine

Supersaturation is the initial and most important step in the formation of urinary stones. Urine normally contains various dissolved substances such as calcium, oxalate, phosphate, uric acid, and cystine. When the concentration of these substances increases beyond their normal solubility level, the urine becomes supersaturated. Factors such as dehydration, low urine volume, excessive salt intake, metabolic disorders, and acidic or alkaline urinary pH promote supersaturation.[18] Supersaturated urine creates favorable conditions for crystal formation and stone development.

Crystallization

Crystallization is the process in which dissolved minerals precipitate and form crystals.[19] It occurs in several stages:

Nucleation

Nucleation is the initial formation of tiny crystal nuclei from supersaturated urine. These nuclei act as seeds for further crystal growth. Nucleation may occur spontaneously or may be induced by foreign particles, damaged epithelial cells, bacteria, or other crystals.

Crystal Growth

Once crystal nuclei are formed, additional minerals from the urine deposit onto the surface of these nuclei, causing them to enlarge. Continued deposition of calcium, oxalate, phosphate, or uric acid results in the formation of larger crystals.

Crystal Aggregation

During aggregation, multiple small crystals combine together to form larger crystal masses. Aggregated crystals are more difficult to eliminate through urine and are more likely to remain within the kidneys or urinary tract.

Crystal Adhesion

Crystals may adhere to the renal tubular epithelium due to injury or inflammation of kidney tissues. Oxidative stress and epithelial damage increase crystal attachment and promote stone retention.

Retention of Stones in the Urinary Tract

Retention of crystals within the urinary tract is a critical step in the development of clinically significant stones. Normally, small crystals are flushed out through urine before they can grow larger. However, when crystals adhere to the renal epithelium or become trapped in the renal tubules, they remain in the kidneys and continue to enlarge. Reduced urine flow, urinary obstruction, infection, and anatomical abnormalities further promote crystal retention and stone growth.[20]

Role of Oxidative Stress and Inflammation

Oxidative stress and inflammation play important roles in the pathogenesis of urolithiasis. Reactive oxygen species damage renal epithelial cells, making them more susceptible to crystal adhesion. Inflammatory mediators also contribute to tissue injury and facilitate retention of crystals within the kidneys.[21]

Formation of Clinically Significant Stones

Over time, retained crystals continue to grow by accumulation of mineral deposits and eventually form larger stones capable of causing pain, hematuria, urinary obstruction, infection, and renal damage. Depending on their composition, stones may consist of calcium oxalate, calcium phosphate, uric acid, struvite, or cystine.[22]

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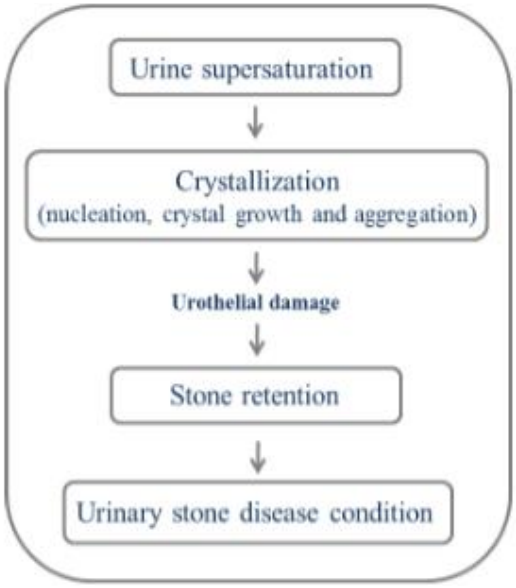

Fig. 1.1 The overall mechanism of urinary stone formation

DIAGNOSIS AND MODERN THERAPEUTIC STRATEGIES FOR MANAGEMENT AND CURE OF URINARY STONES

The medical history of the patient, dietary information, complete blood cell counts, routine urine analyses, and serum creatinine measurements are used to make the diagnosis of urinary stones after a physical examination and taking into account anticipated symptoms of urinary stone illness.[23] Ultrasound and imaging tests like an X-ray or computerised tomography (CT) scan are the key components of the further diagnostic. Because ultrasonography can detect all kidney stone forms, it is favoured in this situation as some kidney stones may not be visible on an X-ray [24].

Urinary stones frequently pass on their own. As a result, doctors frequently attempt to control the early stages of stone disease symptoms, which include analgesic pain management. However, the speed of stone transit varies greatly depending on the size and placement of the stone. Medical expulsive therapy is typically preferred if the stone cannot pass naturally. This treatment plan may call for the administration of antibiotics, calcium antagonists, painkillers, andanti-inflammatory medications [25]. However, when conservative treatment fails owing to the complexity and bigger size of the stones, or when the patient cannot tolerate the level of agony until the stone passes, surgical intervention becomes essential.[26]

Extracorporeal shock wave lithotripsy (ESWL), ureteroscopy (URS), percutaneous pithotripsy (PCNL), and open surgery are the most common surgical procedures. Despite their many benefits, these surgical methods have certain limitations because stone clearance depends on the patient's age, the size, position, and number of the stones as well as radiological renal characteristics and congenital renal defects [27]. Another significant risk factor for surgical and drug treatments is the return of stones [28]. According to research, ESWL may result in acute renal injury because of the traumatic shockwave effect and potential for infection after treatment [29].

COMPLEMENTARY/ALTERNATIVE MEDICINES FOR THE TREATMENT OF URINARY STONES

For the treatment of urinary stone disorders, numerous treatment plans have been established in recent decades. However, the majority of these treatments require surgery, making them costly and occasionally scarce. Due to this, many individuals prefer or are limited to using traditional herbal remedies to cure urinary stones. Ayurveda, Traditional Chinese medicine (TCM), Siddha, and Unani are just a few of the traditional medical systems that have described the use of various herbal treatments to treat urinary stone problems.

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HERBAL MEDICINES FOR THE TREATMENT OF KIDNEY STONES

The Sanskrit word "ayurveda" means "knowledge of life span." It is one of the earliest known medical systems, having its roots in the Indian subcontinent some 3,000 years ago [30]. It is based on the Panchmahabhutas doctrine, which states that all things and living things are made of the five fundamental elements of earth, water, fire, air, and sky [31]. Each person's body (prakriti), which consists of three doshas or bodily humours (vata, pitta, and kapha), and how their imbalance results in illness situations, is the foundation of Ayurvedic remedies [32].

Urolithiasis has been regarded as one of the eight most problematic disorders, and urinary stones are typically referred to in Ayurveda as mutraashamari (mutra-urine; ashma-stone; ari-enemy) (mahagad). Four different forms of urinary calculi, including phosphatic stones (sleshmaashmari), urate stones (pittaashmari), oxalate stones (vataashmari), and spermolith or seminal concretions (sukraashmari), have been recorded in Ayurvedic writings. Herbal remedies, alkaline drinks, and surgical techniques are used in Ayurvedic medicine to treat and manage urinary stones.

For the treatment of urinary stone illnesses, Ayurveda prescribes Shodhana (external and internal oleation, and induction of sweating), Shamana therapy, and panchakarma treatments such medicated emesis, purgation, and enemas. This primarily refers to the oral prescription of herbal medications such as mutrala dravyas (diuretics), ashmari bhedana (linthnotriptic), and teekshna ushna (penetrative) [33].

POLYHERBAL FORMULATIONS IN THE MANAGEMENT OF KIDNEY STONES

Polyherbal formulations play a significant role in the treatment and prevention of kidney stones (urolithiasis) due to their synergistic therapeutic effects, multi-target action, and improved safety profile compared to single-herb and synthetic formulations. Traditional systems of medicine such as Ayurveda and Unani commonly use combinations of medicinal plants to enhance efficacy and minimize adverse effects. Herbs like Punarnava, Pashanbheda, Gokshura, and Varuna work together to provide diuretic, stone-dissolving, anti-inflammatory, and stone-expelling activities, resulting in comprehensive management of kidney stones.

Kidney stone formation is a complex process involving supersaturation of urine, crystal nucleation, aggregation, oxidative stress, and inflammation. Polyherbal formulations act on multiple pathways simultaneously by increasing urine output, inhibiting crystal formation and aggregation, reducing oxidative stress, and protecting renal tissues. Their lithotriptic, diuretic, and antispasmodic properties also help dissolve stones, flush out crystals, and facilitate painless stone expulsion.

Another important advantage of polyherbal formulations is their ability to reduce the recurrence of kidney stones. Unlike surgical procedures and synthetic drugs that mainly remove existing stones, polyherbal formulations help maintain urinary balance, reduce oxalate deposition, and improve kidney function, thereby preventing future stone formation. Many medicinal plants used in these formulations also possess nephroprotective properties that protect renal tissues from crystal-induced injury and inflammation.[34]

Polyherbal formulations are generally safer, less toxic, and better tolerated than synthetic drugs and invasive procedures. They produce fewer side effects and are suitable for long-term use. Polyherbal liquid formulations also improve patient compliance due to their pleasant taste, easy administration, rapid absorption, and convenient dose adjustment, especially in pediatric and geriatric patients. Polyherbal formulations are cost-effective and possess strong antioxidant and anti-inflammatory activities due to phytoconstituents such as flavonoids, saponins, alkaloids, and phenolic compounds. These properties help protect renal tissues and prevent stone formation. Therefore, polyherbal formulations represent a promising and effective alternative for the long-term management and prevention of urolithiasis. [35]

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MEDICINAL PLANTS USED IN HERBAL FORMULATIONS TO CURE KIDNEY STONES

SR. NO.	BOTANICALNAMEANDFAMILY	SANSKRITNAME	PARTUSED	DOSE/MODE OF PREPARATION
1.	*Aervalanata*(L.)Juss.(Amaranthaceae)	Gorakshaganja, Astmabayda,Bhadra, Pashanabheda,Pattura	Whole plant	Whole plant
2.	*Anisomelesmalabarica*(L.)R. Br.exSims(Lamiaceae)	Sprkka	Whole plant	3-5g,powder
3.	*Anogeissuslatifolia*Wall.ex Guillem.& Perr. (Combretaceae)	Dhava	Stembark	30-50ml,decoction
4.	*Apiumgraveolens* L. (Apiaceae)	Karaphsa	Root	5-7g,powder
5.	*Asparagusofficinalis*L. (Liliaceae)	Dvipantara	Root	3-6g,powder
6.	*Baliospermmsolanifolium* (Burm.) Suresh(Euphorbiaceae)	Satavari Hastidanti	Root	1-3g,powder
7.	*Benincasahispida* (Thunb.) Cogn.(Cucurbitaceae)	Kushmand	Fruits	5-10g,powder
8.	*Bergeniacilliata*(Haw.)Sternb. (Saxifragaceae)	Asmabhedaka	Rhizome	3-6g,powder
9.	*Boerhavia diffusa L.* (Nyctaginaceae)	Punarnava	Whole plant / Root	3–6 g powder / 20–40 ml decoction
10.	*Buteamonosperma*(Lam.) Taub.(Lam.)(Leguminosae)	Palasah	Seed	0.5-1g,powder
11.	*Calamusrotang*L.(Arecaceae)	Vetra	Rhizome	50-100ml,decoction
12.	*Caricapapaya*L.(Caricaceae)	Erandkarkati	Root	5-10g,powder 2-6g,powder
13.	*Carthamustinctorius*L.(Compositae)	Kusumbha	FruitLeaves	2-4g,powder
14.	*Cassiafistula*L.(Leguminosae)	Krtamalaka	Stembark	50-100ml,decoction
15.	*Celosiaargentea*L. (Amaranthaceae)	Sitavaraka	Seed	3-6g
16.	*Crataeva nurvala Buch.-Ham.* (Capparaceae)	Varuna	Stem bark	20–40 ml decoction / 3–6 g powder
17.	*Cosciniumfenestratum* (Gaertn.)Colebr.	Kalambaka	Root/Stem	-
18.	*Tribulus terrestris L.* (Zygophyllaceae)	Gokshura	Fruit / Whole plant	3–6 g powder / 20–50 ml decoction

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