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MODERN DIAGNOSTIC AND THERAPEUTIC APPROACHES IN UROLITHIASIS: A LITERATURE REVIEW

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Introduction

Urolithiasis (urinary stone disease) is one of the most common diseases of the urinary system, characterized by the formation of stones of varying chemical composition in the kidneys, ureters, urinary bladder, and urethra. This condition affects approximately 5–15% of the global population, and its prevalence has been increasing in recent years. The development of the disease is influenced by climatic conditions, dietary habits, metabolic disorders, genetic predisposition, and lifestyle factors.

Urolithiasis is considered one of the most relevant problems in modern urology. The disease not only reduces patients' quality of life but may also lead to temporary disability, chronic renal failure, and other severe complications. In particular, the recurrence rate of urolithiasis is high, with stone recurrence observed in 30–50% of patients within 5 years after treatment and in 50–70% within 10 years.

In recent years, advances in diagnostic and therapeutic technologies have significantly improved the detection and management of urolithiasis. The development of multislice computed tomography, ultrasonographic diagnostics, and laboratory investigations has enabled early detection of the disease. Furthermore, minimally invasive techniques such as extracorporeal shock wave lithotripsy (ESWL), ureterorenoscopy (URS), retrograde intrarenal surgery (RIRS), and percutaneous nephrolithotomy (PCNL) have significantly reduced the need for open surgical interventions.

Therefore, the study of modern diagnostic and therapeutic approaches in urolithiasis, as well as the analysis of their advantages and clinical significance, represents an important scientific and practical task.

Aim of the Study

To analyze the effectiveness of modern diagnostic and therapeutic approaches used in urolithiasis based on published scientific literature.

Objectives of the Study

- To investigate the etiology and pathogenesis of urolithiasis;
- To evaluate the capabilities of modern diagnostic methods;
- To analyze conservative and surgical treatment strategies;
- To review prevention strategies and measures for recurrence reduction.

Pathogenesis of Urolithiasis

Urolithiasis is a polyetiological disease in which multiple internal and external factors contribute to its development. Stones are formed as a result of crystallization of mineral salts and organic substances present in urine. The process of stone formation is based on complex biochemical and physicochemical reactions.

Under normal conditions, urine contains various dissolved minerals. Under certain circumstances, the concentration of these substances increases, leading to supersaturation of urine. As a result, crystals form, aggregate, and gradually grow into stones.

The main stages of stone formation include the supersaturation of urine with mineral salts, followed by the formation of crystal nuclei (nucleation). This is subsequently accompanied by crystal growth and aggregation, which leads to the progressive enlargement of crystalline structures. Over time, these crystals are retained within the urinary tract, where they continue to accumulate. Ultimately, this process results in the formation of a fully developed urinary stone. Metabolic disorders are among the most important causes of urolithiasis.

- **Hypercalciuria** – excessive excretion of calcium in urine, a major factor in calcium stone formation.
- **Hyperoxaluria** – increased urinary oxalates leading to calcium oxalate stones.
- **Hyperuricosuria** – impaired uric acid metabolism resulting in urate stones.
- **Hypocitraturia** – reduced citrate levels decrease natural inhibition of crystallization and increase stone risk.

Studies have shown that genetic predisposition plays an important role in some patients. Individuals with a family history of urolithiasis have a higher risk of developing the disease. Inherited metabolic disorders such as cystinuria and primary hyperoxaluria may also lead to stone formation.

Urolithiasis is more common in populations living in hot climates. Increased environmental temperature leads to dehydration, increased urine concentration, and favorable conditions for crystallization. Central Asian countries, including Uzbekistan, are considered endemic regions for urolithiasis.

Dietary habits also play a significant role. Excessive consumption of salt, protein-rich foods, and oxalate-containing products increases the risk of stone formation.

Risk factors include low fluid intake, excessive salt consumption, obesity, sedentary lifestyle, high intake of animal proteins, diabetes mellitus, and metabolic syndrome.

Types of Urinary Stones

- Calcium oxalate stones – 70–80%
- Calcium phosphate stones – 10–15%
- Uric acid (urate) stones – 5–10%
- Struvite stones – associated with infections
- Cystine stones – observed in hereditary metabolic disorders

Determining stone composition is essential for selecting appropriate treatment and preventive strategies.

Diagnostic Methods

Effective management of urolithiasis requires assessment of stone location, size, number, density, and composition. Modern diagnostic methods allow early detection and appropriate treatment planning. Diagnosis includes clinical, laboratory, and instrumental approaches.

Clinical Diagnosis

Clinical manifestations depend on stone location, size, and degree of urinary obstruction.

The main symptoms include severe lumbar pain (renal colic), radiating pain to the lower abdomen and genital region, urinary disturbances, hematuria, nausea, vomiting, and fever in cases of infection.

Renal colic is the most characteristic symptom of urolithiasis. Pain occurs suddenly, is extremely intense, and is often not relieved by standard analgesics or antispasmodics.

Medical history should include previous episodes of stone disease, surgical interventions, family history, dietary habits, fluid intake, and comorbid conditions such as gout, diabetes mellitus, and obesity.

Physical examination includes assessment of costovertebral angle tenderness (Pasternatsky sign), evaluation of lumbar pain, body temperature, and general condition.

Laboratory Diagnosis

Laboratory tests play an important role in identifying the cause of stone formation and assessing renal function.

Urinalysis may reveal erythrocytes (micro- or macrohematuria), leukocytes, crystal salts, and proteinuria. Crystal type may suggest stone composition.

Urine culture is performed in suspected infection-related stones to identify microorganisms and determine antibiotic sensitivity.

Blood biochemical analysis includes creatinine, urea, calcium, phosphorus, uric acid, and electrolytes, which are essential for evaluating renal function and metabolic disorders.

In recurrent cases, a 24-hour urine analysis is recommended to measure calcium, oxalate, citrate, phosphate, and uric acid levels. This helps in developing individualized preventive strategies.

Instrumental Diagnosis

Ultrasound examination (US) is the first-line diagnostic tool for urolithiasis. It is non-invasive, safe, inexpensive, and fast. It can detect renal stones, hydronephrosis, and urinary tract dilation; however, it has limited sensitivity for small ureteral stones.

Excretory urography and abdominal radiography can detect radiopaque stones. However, they cannot visualize radiolucent stones.

Non-contrast spiral computed tomography (CT) is currently considered the gold standard diagnostic method. It provides accurate localization, size measurement, density assessment, and evaluation of obstruction severity, with sensitivity and specificity approaching 95–100%.

Multislice CT (MSCT) is one of the most informative modern imaging techniques, allowing high-resolution, three-dimensional reconstruction and surgical planning.

Magnetic resonance imaging (MRI) is less commonly used for stone detection and is mainly indicated in pregnant patients or when radiation exposure must be avoided.

Modern Treatment Methods

The primary goals of urolithiasis treatment are stone elimination, restoration of urinary flow, pain relief, infection control, and prevention of recurrence. Treatment depends on stone size, location, composition, and the patient's general condition.

Conservative treatment is effective for small stones (up to 5–6 mm).

Dietary therapy includes increased fluid intake (2–2.5 L/day), salt restriction, moderation of animal protein intake, and reduction of oxalate-rich foods.

Pharmacological treatment includes NSAIDs (diclofenac, ketorolac, ibuprofen) for pain relief, antispasmodics (drotaverine, papaverine) for ureteral spasm, and alpha-blockers (tamsulosin) to facilitate stone passage.

Minimally invasive techniques have become the mainstay of modern treatment:

Extracorporeal Shock Wave Lithotripsy (ESWL)

ESWL uses externally generated shock waves to fragment stones. It is indicated for renal and ureteral stones up to 20 mm. It is non-invasive and performed on an outpatient basis; however, its effectiveness decreases in large or hard stones.

Ureterorenoscopy (URS)

URS involves endoscopic access to the ureter for direct visualization and stone extraction. It offers high success rates and short recovery time.

Retrograde Intrarenal Surgery (RIRS)

RIRS uses a flexible ureteroscope and laser lithotripsy to treat renal stones. It is minimally invasive and effective for complex stone locations.

Percutaneous Nephrolithotomy (PCNL)

PCNL is used for large renal stones (>20 mm) and staghorn calculi. It provides a high stone-free rate in a single procedure.

Laparoscopic techniques are used in selected complex cases, offering reduced blood loss and faster recovery. Open surgery is now rarely performed and is reserved for extremely large stones, anatomical abnormalities, or failed minimally invasive procedures.

Prevention and Recurrence Control

A key characteristic of urolithiasis is its high recurrence rate. Studies show recurrence in 30–50% of patients within 5 years and up to 70% within 10 years.

The most important preventive measure is adequate hydration. Increased fluid intake reduces urinary supersaturation and crystal formation.

Dietary modification depends on stone type:

- Calcium oxalate stones: restriction of spinach, sorrel, chocolate, cocoa, nuts
- Uric acid stones: reduction of red meat and purine-rich foods
- Phosphate stones: control of dairy intake and urinary pH

Pharmacological prevention may include potassium citrate (hypocitraturia), allopurinol (hyperuricemia), and thiazide diuretics (hypercalciuria).

Regular metabolic evaluation and follow-up are essential for recurrence prevention.

Conclusion

Urolithiasis remains one of the most significant challenges in modern urology due to its high prevalence, recurrent nature, and potential to impair renal function.

Modern diagnostic methods, particularly ultrasound and non-contrast computed tomography, provide highly accurate detection and characterization of urinary stones.

Minimally invasive surgical techniques such as ESWL, URS, RIRS, and PCNL have revolutionized treatment by improving outcomes, reducing complications, and shortening hospital stays. Open surgery is now reserved for selected complex cases.

Preventive strategies, including adequate hydration, dietary modification, metabolic correction, and regular follow-up, play a crucial role in reducing recurrence rates.

Thus, the application of modern diagnostic and therapeutic technologies significantly improves patient outcomes, reduces complications, and prevents recurrence of urolithiasis.

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