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# APPROACHES TO THE DIAGNOSIS AND MANAGEMENT OF UROLITHIASIS: A LITERATURE REVIEW

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**Abstract**

Urolithiasis is one of the most common urological conditions encountered in clinical practice and continues to show a rising global trend. The wide variation in clinical presentation, along with rapid advances in diagnostic and therapeutic technologies, necessitates a comprehensive understanding of its management approaches. This literature review aims to summarize recent developments in the diagnosis and management of urolithiasis and to compare the effectiveness of various interventional modalities. A narrative literature review was conducted using articles published between 2022 and 2025, identified through PubMed and Google Scholar. Keywords included urolithiasis, diagnosis, management, ESWL, URS, and PCNL. Relevant articles were selected based on topical relevance, publication quality, and availability of clinically meaningful data. Non-contrast CT scan remains the most accurate diagnostic modality for detecting urinary stones, whereas ultrasonography remains valuable in specific populations and resource-limited settings. In terms of treatment, ESWL is effective for small to medium-sized stones with low density, URS demonstrates higher success rates for ureteral stones, and PCNL remains the primary option for large or complex stones. Recurrence prevention through metabolic evaluation, dietary modification, and pharmacologic therapy significantly reduces the risk of stone formation. Diagnostic and therapeutic strategies for urolithiasis have advanced considerably; However, optimal modality selection must be tailored to individual patient and stone characteristics. Personalized approaches and sustained preventive strategies are essential to improving clinical outcomes and reducing recurrence rates.

***Keywords:Urolithiasis; Diagnosis; Computed Tomography; Extracorporeal Shock Wave Lithotripsy; Ureteroscopy; Percutaneous Nephrolithotomy.***

## INTRODUCTION

Urolithiasis is one of the most common urological health problems worldwide, with incidence rates steadily increasing over the past two decades. This disease is characterized by the formation of stones in various parts of the urinary tract, such as the kidneys, ureters, bladder, and urethra, due to the precipitation of mineral crystals and organic matter in the urine. Risk factors for urolithiasis are diverse, including genetic predisposition, a diet high in oxalate and salt, low fluid intake, obesity, and metabolic conditions such as hyperparathyroidism and calcium metabolism disorders. These variations in factors lead to differences in stone characteristics and clinical manifestations between individuals and populations.(Allam, 2024) Clinically, urolithiasis can cause typical symptoms of renal colic pain, hematuria, urinary tract infections, and even urinary tract obstruction, potentially leading to impaired kidney function. Therefore, a timely and accurate diagnosis is crucial to preventing further complications. Advances in diagnostic technology such as non-contrast CT scans, ultrasound, and urine metabolic analysis have improved the accuracy of stone identification and the etiology of their formation.(Alnadhari et al., 2025; Dika et al., 2025; Jun et al., 2022) In terms of management, approaches to urolithiasis have evolved significantly in recent years. Treatment can range from conservative therapies such as hydration and medication to minimally invasive interventions such as extracorporeal shock wave lithotripsy (ESWL), ureteroscopy, and percutaneous nephrolithotomy (PCNL). The choice of therapy depends largely on the size, location, and composition of the stone, as well as the patient's clinical condition. In addition to acute therapy, preventing recurrence through lifestyle modification and metabolic management is also an important part of long-term management.(Pozdzik et al., 2024)

## METHOD

This literature review was compiled using a narrative approach to summarize current information on the diagnosis and management of urolithiasis. The literature search was conducted through several electronic sources, including PubMed, Google Scholar, and ScienceDirect. Keywords used included "urolithiasis," "urinary stones," "diagnosis," "management," and "treatment." Articles considered in this review included publications in English and Indonesian published between 2022 and 2025. The literature types used included research articles, literature reviews, clinical guidelines, and textbooks relevant to the topic. Literature unrelated to the diagnosis or management of urolithiasis, as well as articles without full-text access, were excluded from the review. Following the search process, literature meeting the criteria was reviewed and analyzed to extract key information regarding diagnostic methods, imaging technology developments, therapeutic options, and clinical recommendations used in the management of urolithiasis. The review results were then synthesized narratively to provide a comprehensive and accessible understanding of current clinical practices related to urolithiasis.

## RESULTS

A literature review shows that the diagnosis of urolithiasis has undergone significant developments in imaging techniques and metabolic evaluation approaches. Non-contrast CT scans remain the most accurate diagnostic modality, with high sensitivity and specificity for detecting stones in all segments of the urinary tract. Ultrasonography remains the initial choice in certain conditions, such as pregnancy or limited facilities, although it is less sensitive for small stones. Urinalysis and metabolic evaluation are also considered crucial, especially in patients with a history of recurrence, as they can identify metabolic disorders contributing to stone formation, such as hyperoxaluria, hypercalciuria, and hyperuricemia.(Allam, 2024; Dika et al., 2025) In terms of management, the literature shows a variety of approaches tailored to the size, location, and composition of the stone. Small stones (less than 5 mm) can generally be managed conservatively with adequate hydration, analgesics, and medication therapy such as alpha-blockers to help expedite stone passage. For larger stones, minimally invasive interventions are the primary option. Extracorporeal shock wave lithotripsy (ESWL) has been found to be effective for small to medium-sized kidney stones, especially those with low density. Ureteroscopy (URS) is an option for ureteral stones and kidney stones unresponsive to ESWL. Percutaneous nephrolithotomy (PCNL) is recommended for large, complex, or staghorn stones, as it offers a higher success rate in clearing the stones.(Güven et al., 2022; Pozdzik et al., 2024) In addition to acute treatment, the literature also emphasizes the importance of long-term prevention. Lifestyle modifications, increased fluid intake, and dietary adjustments have been found to be effective in reducing the risk of recurrence. In patients with certain metabolic abnormalities, pharmacological therapies such as thiazides, citrates, or allopurinol have been shown to be beneficial in reducing new stone formation.(Jahrreiss et al., 2024) The study results show that the selection of appropriate diagnostic and treatment modalities depends heavily on the stone characteristics and the patient's clinical condition. A combination of imaging approaches, individualized therapy, and metabolic prevention provides optimal clinical outcomes in the management of urolithiasis.(Arnold et al., 2020; Güven et al., 2022)

**Table1 Literature Review**

| No | Researcher & Year | Journal Title | Key Findings |
|---|---|---|---|
| 1 | Pozdzik et al., 2024 | *Gaps in Kidney Stone Disease Management* | There is a significant gap between clinical theory and practice. Many patients do not achieve fluid intake targets, dietary adherence is poor, and 24-hour urine monitoring is rarely performed. This highlights the need for better education and long-term monitoring. |
| 2 | Allam, 2024 | *Urolithiasis Unveiled: Pathophysiology and Stone Dynamics* | Describe the mechanisms of stone formation, including urinary supersaturation, pH changes, and crystallization inhibitor factors. This knowledge is essential for determining appropriate preventive therapy. |
| 3 | Jahrreiss et al., 2023 | *Medical Management of Urolithiasis* | Medical management has been slow to evolve due to poor patient compliance. Drugs such as thiazides, citrates, and allopurinol remain effective, but therapy must be individualized based on the patient's metabolic profile. |
| 4 | Dika et al., 2025 | *Treatment of Urolithiasis: A Comprehensive Review* | The global trend is toward minimally invasive interventions. URS and PCNL have shown high success rates for a wide range of stone sizes. Recurrence prevention places greater emphasis on diet, hydration, and long-term metabolic therapy. |

**1). Diagnosis**

Diagnosis of urolithiasis is aimed at identifying the presence of stones, determining their location and size, and evaluating the degree of obstruction and complications. The diagnostic approach includes anamnesis, physical examination, laboratory analysis, and imaging as the primary modalities.

**Anamnesis**

The classic complaint is intermittent renal colic pain that radiates as the stone moves along the ureter. Hematuria, both microscopic and gross, is found in most cases. Irritant symptoms such as urgency, dysuria, and frequency occur if the stone is located in the distal ureter. A history of gout, use of certain medications, or low fluid intake increase the risk of stone formation. Fever or chills indicate an obstructive urinary tract infection that requires immediate attention.(Manciulli et al., 2023)

**Physical examination**

Physical examination is generally nonspecific, but costovertebral angle tenderness (CVAT tenderness) is a common finding. Signs of dehydration may arise from vomiting or decreased fluid intake. Fever indicates the possibility of obstructive pyelonephritis, which can progress to urologic sepsis.

**Laboratory Examination**

Urine and blood tests are used to assess complications, predict stone type, and evaluate metabolic etiology. Urinalysis may reveal hematuria, leukocyturia, or a positive nitrite test in cases of infection. Identification of urinary crystals provides clues to the type of stone, such as calcium oxalate or uric acid. Urine pH testing aids in metabolic classification, with a low pH suggesting uric acid stones, while a high pH is associated with struvite stones. Blood tests, including creatinine, urea, electrolytes, calcium, phosphate, and uric acid, can identify underlying metabolic disorders leading to stone formation.(Anderegg et al., 2024; Lim et al., 2022)

**Imaging Examination**

Imaging modalities are a key component in the diagnosis of urolithiasis. Non-contrast CT (NCCT) is the gold standard with very high sensitivity and specificity and is capable of identifying radiolucent stones. This examination also provides information on stone size and density, which are important in determining treatment. Ultrasonography (USG) is preferred in children, pregnant women, or patients requiring repeated examinations because it does not involve radiation exposure. USG is effective in detecting hydronephrosis, although its sensitivity is lower for ureteral stones. Plain abdominal radiography (KUB) is still used to assess radiopaque stones, particularly calcium, and is useful for monitoring. Intravenous urography (IVU) is now rarely used but can provide insight into kidney function and the extent of obstruction.(Güven et al., 2024; Naeverdal et al., 2023)

**Table2Summary of Urolithiasis Diagnosis**

| Diagnostic Components | Description |
|---|---|
| **Anamnesis** | Renal colic pain (intermittent, radiating to the inguinal), hematuria, dysuria/urgency if the stone is distal, nausea and vomiting, history of previous stones, history of gout, poor hydration, high salt/protein intake. If fever is suspected, an obstructive infection may be present. |
| **Physical examination** | Costovertebral angle tenderness (CVA), signs of dehydration (decreased turgor, dry mucosa), fever if infected, lower abdominal pain in distal ureteral stones. Physical findings are often nonspecific. |
| **Urinalysis** | Microscopic/macroscopic hematuria, leukocyturia, positive nitrite (infection), identification of crystals (oxalate, urate, cystine), urine pH (low indicates urate stones; high → struvite/cystine stones). |
| **Blood Test** | Creatinine & urea (assess kidney function), electrolytes, calcium, phosphate, magnesium, uric acid. Used for metabolic evaluation and possible obstruction. |

| | |
|---|---|
| **24-Hour Stone/Urine Analysis** | Metabolic evaluation of recurrent stones: calcium, oxalate, citrate, uric acid, urine volume, sodium. Used for prevention and determining medical therapy. |
| **Ultrasonography (USG)** | Initial modality for detecting hydronephrosis, kidney stones, and proximal ureteral stones. Radiation-free. Low sensitivity for distal ureteral stones. |
| **Plain Abdominal Photo (KUB)** | Detects radiopaque stones (calcium, struvite). Does not detect radiolucent stones (uric acid). Useful for follow-up after ESWL/monitoring. |
| **Non-Contrast CT (NCCT) – The Gold Standard** | Sensitivity & specificity >95%. Assesses stone size, density (HU), location, hydronephrosis, and differential diagnosis of acute pain. The modality of choice in acute renal colic. |
| **Contrast CT (CT-IVP/CTU)** | Used when the diagnosis is unclear, to assess kidney function and anatomy. Not routine due to radiation and contrast risks. |
| **IVU (Intravenous Urography)** | Now rarely used. Can assess kidney function, obstruction, and anatomy. Replaced by CT. |

**Table3Comparison of Imaging Modalities**

| Modality | Superiority | Limitations | Main Indications |
|---|---|---|---|
| **ultrasound** | Radiation-free, safe for pregnant women and children, detects hydronephrosis | Low sensitivity for ureteral stones, operator dependent | Initial screening; follow-up monitoring |
| **KUB X-ray** | Inexpensive, easily accessible, radiopaque stone detection | Does not detect radiolucent stones, low sensitivity | Calcium stone monitoring, ESWL follow-up |
| **NCCT (CT without contrast)** | Gold standard; detection of almost all types of stones; evaluation of density & location | Radiation, higher costs | Acute renal colic; stones not detected by USG/KUB |
| **Contrast CT (CTU/CT-IVP)** | Evaluation of renal function, ureteral anatomy, differential diagnosis | Contrast & radiation exposure, not routine | Complex cases, specific pre-operative evaluation |
| **IVU** | Assess kidney function & obstruction | It's rarely used, beaten by CT | Limited situation without CT access |

**2). Management**

Treatment for urolithiasis aims to relieve obstruction, manage pain, prevent infection, and reduce the risk of recurrence. The choice of therapy is based on stone size, location, composition, degree of obstruction, renal status, and overall clinical condition. General management strategies include conservative approaches, medication, and urologic interventions.(Savin et al., 2024)

**Conservative Management**

Conservative management is preferred for uncomplicated cases, especially for stones <5 mm in diameter. Key components include:

1. **Optimal Hydration**
   Increased fluid intake is recommended to produce urine output of ≥2–2.5 L/day. High urine output increases urine flow, decreases mineral saturation, and facilitates stone excretion. Recent literature emphasizes the importance of hydration adherence education, as many patients fail to maintain adequate daily fluid intake.
2. **Analgesic**

NSAIDs such as ketorolac, diclofenac, or ibuprofen are first-line therapy. NSAIDs work by lowering intrarenal pressure by inhibiting prostaglandin synthesis. Opioids are only given if pain is uncontrolled, especially in patients with contraindications to NSAIDs.

3. **Regular Monitoring**
   Patients are monitored with ultrasound or CT to ensure the stone is not impacted or causing progressive hydronephrosis. Worsening symptoms or signs of infection are indications for switching to active therapy.

**Medical Expulsive Therapy (MET)**
MET is a supportive therapy to facilitate the passage of ureteral stones measuring 5–10 mm. Primary agents include:

1. **Tamsulosin**
   As an α1-blocker, tamsulosin increases ureteral peristalsis and reduces smooth muscle spasm. MET with tamsulosin has been shown to improve expulsion success rates, particularly for distal ureteral stones. The duration of therapy ranges from 4–6 weeks with clinical monitoring.
2. **Nifedipine**
   This calcium channel blocker can be used as an alternative, although its effectiveness is less than that of tamsulosin. Side effects such as hypotension limit its use.
3. **Contraindications of MET**
   MET is not recommended in patients with urinary tract infections, uncontrolled pain, bilateral obstruction, or progressive renal impairment.(Zeng et al., 2023)

**Preventive Medical Therapy**
Preventing stone recurrence requires a thorough metabolic evaluation (24-hour urine and blood metabolic profile). Some preventive modalities include:

1. **Diet Modification**

- Water intake: ≥2–3 L/day.
- Sodium restriction <2 g/day to reduce urinary calcium excretion.
- Animal protein is reduced because it increases the excretion of uric acid and calcium.
- Calcium intake should not be excessively restricted; the recommendation remains 1,000–1,200 mg/day from food.
- Restriction of oxalate (spinach, chocolate, nuts) in calcium oxalate stones.

2. **Metabolic Pharmacotherapy**

- **Thiazides (hydrochlorothiazide, chlorthalidone)**reduce hypercalciuria.
- **Potassium citrate**increases urine pH and inhibits crystallization; effective on uric acid stones, calcium oxalate stones, and cystine stones.
- **Allopurinol**used in hyperuricosuria or hyperuricemia.
- **Alkalinization of urine**recommended for dissolving uric acid stones with a target urine pH of 6.5–7.0.

3. **Periodic Evaluation**
   Repeat 24-hour urine analysis is performed at least 6 months after medical intervention to ensure the effectiveness of metabolic changes.(Scotland et al., 2022)

**Urological Interventions**
Intervention is performed in cases of large stones, failure of conservative therapy, severe obstruction, obstructive infection, or impaired kidney function.

**Extracorporeal Shock Wave Lithotripsy (ESWL)**
ESWL is a non-invasive therapy that breaks up stones with shock waves. Indications include kidney stones <20 mm in the renal calyces or pelvis, and some ureteral stones.
Success is influenced by:

- Rock size and density (Hounsfield Unit <1,000 is more responsive).

- Distance from skin to stone.
- Location of the stone (inferior calyx has a lower success rate).

Side effects include hematuria, post-ESWL colic, and Steinstrasse. ESWL remains popular due to its quick recovery time and low risk of complications.

**Ureteroscopy (URS)**
Flexible and semirigid ureteroscopy with a holmium laser is becoming the standard for ureteral stones and small kidney stones.
The advantages of URS include:

- High stone-free level.
- Good for hard stones such as calcium oxalate monohydrate stones.
- Can be performed on patients with obesity or relative bleeding disorders.

Complications are rare but include ureteral perforation, stricture, infection, and hematuria.(Lasorsa et al., 2023)

**Percutaneous Nephrolithotomy (PCNL)**
PCNL is the primary choice for:

- Stone ≥20 mm
- Staghorn rock
- Stones with complex anatomy

Mini-PCNL, ultra-mini-PCNL, and micro-PCNL techniques reduce bleeding and morbidity while maintaining high success rates. Risks of PCNL include bleeding, infection, and intraperitoneal organ injury, but are relatively low in experienced centers.

**Urgent Drainage (Ureteral Stent / Nephrostomy)**
In obstructive infections (urosepsis), drainage should be performed immediately before definitive therapy. Percutaneous nephrostomy often reduces urinary system pressure more quickly, while ureteral stents are effective if ureteral access is possible.(Al-Shawi et al., 2022)

**Modality Selection Based on Stone Size and Location**

- ≤5 mm: conservative ± MET
- 5–10 mm: MET, URS, or ESWL
- >10–20 mm: URS or ESWL, depending on the location and density of the stone
- ≥20 mm or staghorn: PCNL
- Obstructive infection: nephrostomy or stent then continue definitive therapy after stabilization

**Table4 Summary of Urolithiasis management**

| Aspect | Description |
|---|---|
| **The main purpose** | Relieves obstruction, reduces pain, treats infection, and prevents stone recurrence. |
| **Conservative** | Indications: stones ≤5 mm, without infection, without significant obstruction. Therapy: hydration ≥2 L/day, NSAIDs, USG/CT monitoring. |
| **Medical Expulsive Therapy (MET)** | Indications: distal ureteral stones 5–10 mm. Medications: tamsulosin (primary), nifedipine (alternative). Not recommended for infections or uncontrolled pain. |
| **Preventive Therapy** | Diet modification (high water, low sodium, moderate protein), thiazides for hypercalciuria, potassium citrate for low pH, allopurinol if hyperuricosuria. |
| **ESWL** | Indications: kidney stones <20 mm, certain ureteral stones |

**Table5 Comparison of ESWL, URS and PNC**

| Parameter | ESWL | URS | PCNL |
|---|---|---|---|
| **Level of invasiveness** | Non-invasive | Minimally invasive | Invasive |
| **Anesthesia** | Generally without general anesthesia | Spinal / general anesthesia | General anesthesia is mandatory |
| **Main indications** | Kidney stones <20 mm, certain ureteral stones | Distal/proximal ureteral stones, small–medium kidney stones | Stones ≥20 mm, staghorn stones, complex stones |
| **Effectiveness (stone-free rate)** | Medium (influenced by rock density) | Tall | Very high |
| **Excess** | Non-invasive, rapid recovery, low morbidity | High accuracy, can handle almost any stone location | Highest effectiveness for large/complex stones |
| **Limitations** | Less effective for hard stones (HU >1,000), inferior locations | Risk of ureteral perforation, stricture, infection | Risk of bleeding, infection, longer hospital stay |
| **Major complications** | Hematuria, post-procedural colic, steinstrasse | Ureteral injury, infection, hematuria | Bleeding, damage to surrounding organs, sepsis |
| **Special tool requirements** | Shock wave machine | Flexible/semi-rigid ureteroscope + holmium laser | Percutaneous access + dilator + lithotripter |
| **Recovery duration** | Very fast | Fast | Longer than ESWL/URS |
| **Relative costs** | Generally lower | Currently | Highest |
| **Suitability for children/pregnancy** | Relatively safe | Limited | Not recommended |
| **When is it not suitable?** | Large/hard stones, extreme obesity | Anatomical distortion of the ureter, active infection | Uncontrolled coagulation disorders |

## DISCUSSION

Urolithiasis remains one of the most common urological diseases, with varied clinical manifestations and challenges in diagnosis and management. Findings from various literature indicate that advances in imaging technology and interventional techniques have improved diagnostic accuracy and therapeutic effectiveness. However, the choice of method must still be tailored to stone characteristics, patient condition, and facility availability.(Lasorsa et al., 2023; Zeng et al., 2023) From a diagnostic perspective, non-contrast CT scanning (NCCT) is now recognized as the primary modality with high sensitivity and specificity for detecting almost all types of stones. NCCT has become standard, especially in cases of acute colic pain, as it provides comprehensive information on stone size, location, and density, as well as urinary tract obstruction. However, concerns about radiation exposure make ultrasound still relevant, especially in pregnant women, children, and patients requiring repeated examinations. Ultrasound also plays a role as an initial examination in limited healthcare settings. Urinalysis, urine culture, and stone

analysis remain essential in determining the etiology and selecting appropriate therapy.(Scotland et al., 2022; Zeng et al., 2023) In terms of management, a minimally invasive approach is the primary choice in most cases. The literature shows that Extracorporeal Shock Wave Lithotripsy (ESWL) is widely used for small to medium-sized stones, especially kidney stones <20 mm in diameter with low density. The advantage of ESWL lies in its non-invasiveness, but its success rate decreases for hard stones (>1000 HU) and distal ureteral stones.(Manciulli et al., 2023)

Meanwhile, ureterorenoscopy (URS) shows a higher success rate than ESWL for ureteral stones, both proximal and distal. Flexible URS also provides good results for small-to-medium kidney stones, but the risk of complications such as ureteral injury still needs to be considered. This method is gaining popularity thanks to advances in laser technology (Holmium:YAG, Thulium Fiber Laser) which allows for more effective stone fragmentation.(Williams et al., 2021) For large or complex stones, percutaneous nephrolithotomy (PCNL) remains the gold standard, especially for stones >20 mm or staghorn stones. PCNL has a success rate of >90%, but morbidity is higher than ESWL and URS. Innovations such as mini-PCNL help reduce complications while maintaining effectiveness.(Pozdzik et al., 2024) In addition to interventions, recent research emphasizes the importance of recurrence prevention efforts, including dietary modification, increased fluid intake, and pharmacological therapy such as thiazides, citrates, or allopurinol, depending on the stone type. Many studies suggest that recurrence rates can be reduced by up to 50% if a comprehensive metabolic evaluation is performed.(Alnadhari et al., 2025)

## CONCLUSION

Urolithiasis is a condition with increasing prevalence and demands an accurate and integrated approach to diagnosis and management. Based on literature findings, non-contrast CT scan remains the gold standard for diagnosis due to its high sensitivity and specificity, while ultrasound and laboratory tests complement the evaluation process, especially in certain patient groups and with limited facilities. In management, advances in minimally invasive techniques have expanded treatment options. ESWL is effective for small-to-medium, low-density stones, URS offers a higher success rate, especially for ureteral stones, while PCNL remains the best option for large or complex stones. The choice of modality should be tailored to the size, location, and composition of the stone, the patient's clinical condition, and the availability of medical facilities. Recurrence prevention through metabolic evaluation, lifestyle modification, and pharmacological therapy has proven essential in reducing stone recurrence. Overall, optimal urolithiasis management requires an individualized approach, a combination of appropriate diagnostic modalities, and evidence-based therapeutic strategies to improve clinical outcomes and reduce recurrence rates.

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