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Nephrolithiasis: Diagnosis and Management in the Emergency Department

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Kidney stones (nephrolithiasis) have plagued mankind for centuries. Scientists have found kidney stones in mummies dating more than 7000 years old.[1] The pain associated with this disease is uniformly severe and has been compared with that of child birth and other severe pain. Urolithiasis refers to stones found anywhere along the urinary tract and is a common etiology for abdominal and flank pain in patients presenting to the emergency department (ED). Data from 1997 estimate that the prevalence of kidney stones in the United States is 7% in men and 3% in women.[2] This number is likely increasing with the higher consumption of animal protein seen today. The prevalence of kidney stones in the southeastern United States (the "stone belt") is disproportionately high, which is thought to be related to ambient temperature and sunlight exposure.[3] Recurrence rates reach approximately 50% within 10 years of the first kidney stone, and up to 80% of patients have recurrent stones within 20-30 years.[4] They can present at any age, but peak incidence occurs between 20

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and 50 years of age.[5] Prevalence of kidney stones has been linked to multiple factors including, but not limited to, climate, nutrition, heredity, and anatomic defects.[6]

There have been multiple advances in evaluation and management of this disease in recent years. This article will provide the emergency physician with an understanding essential for timely diagnosis, management, and disposition of kidney stones in the ED.

—The Editor

Pathophysiology and Dynamics

There are multiple factors that contribute to the formation of urinary calculi, including urinary supersaturation, paucity of inhibitory factors for stone formation, and facilitatory conditions for crystallization, such as hyperoxaluria or hypercalciuria.[2]

With high solute loads and low urine volume, urine becomes a saturated solution in which no more solute can be dissolved and crystals begin to form. Most of these crystals travel down the collecting systems into the ureters and bladder, and are too small to cause any clinical symptoms. Some crystals can adhere to tubular cells, allowing more time for growth into pathologic stones.[7] When other factors such as low urine flow from dehydration or obstruction, absence of crystal inhibitors (citrate, nephrocalcin, uropontin, pyrophosphate, and others[8]), and hypercalciuria are present, growth of these crystals into kidney stones is facilitated.

Spontaneous passage of kidney stones depends mainly on stone size and, to a lesser extent, stone location. Miller and Kane studied the time to stone passage, measuring variables such as stone size, location, gender, age, and pain medication requirements. They found that stones 2 mm or smaller in diameter passed spontaneously at a mean time of 8.2 days, with 4.8% requiring intervention. Stones between 2 mm and 4 mm passed spontaneously at an average of 12.2 days, with 17% requiring intervention. Finally, a mean of 22.1 days was required for spontaneous passage of stones measuring 4-6 mm, with 50% requiring intervention.[9] A number of articles have addressed the relationship of stone size to spontaneous passage, all of which have varying results. Simply stated, larger stones decrease the chances for spontaneous passage. Stones 4-5 mm in size have about a 50% chance of spontaneous passage, while stones greater than 6 mm typically require urologic intervention 95% of the time.[10]

Kidney stones rarely cause complete obstruction of the ureter.[11] If present, complete obstruction may cause significant irreversible damage to the ipsilateral kidney within 1-2 weeks.[12] After complete or partial obstruction occurs, renal pelvic pressures elevate. This causes a decrease in the glomerular filtration in the ipsilateral kidney and ultimately results in redistribution of blood flow to the opposite kidney for compensation. Because of the contralateral compensation, kidney failure is rare in patients with normal renal anatomy and obstructive kidney stones. Obstruction also leads to urinary stasis, predisposing the patient to infection of the urinary tract. Presence of infection in the face of obstruction is considered by some to be a urologic emergency, and timely urologic consultation should be obtained.

Types of Stones

Urinary calculi may be classified into four different types: calcium-derived stones, struvite stones, uric acid stones, and cystine stones. (*See Table 1.*) Calcium-derived stones account for 70-80% of all stones. Most are a combination of calcium oxalate and calcium phosphate (37%); however, pure calcium oxalate and calcium phosphate stones make up a significant percentage (26% and 7%, respectively).[13] Hyperexcretion of calcium and/or oxalate are major factors in the formation of calcium-containing stones. Many patients suffer from idiopathic hypercalciuria, the cause of which has yet to be found. This appears to be a familial disease and more common in men. Obesity, high protein and salt intake, hyperparathyroidism, and peptic ulcer disease also have been associated with higher urinary calcium excretion.

Struvite stones, or infection stones, are composed of magnesium ammonium phosphate and make up 15-20% of all kidney stones. These are formed by urea-splitting organisms including, but not limited to, Proteus and Providencia species as well as some species of Pseudomonas, Serratia, and Klebsiella. Patients presenting with pure struvite stones rarely have idiopathic hypercalciuria and often have impaired renal function and contralateral kidney involvement. These often present as "staghorn"

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Table 1. Stone Types

STONE TYPE	FREQUENCY	COMMON CAUSES
Calcium	70-80%	• Hypercalciuria
Calcium oxalate		• Hyperparathyroidism
Calcium phosphate		• Renal tubular acidosis
Mixed		• Inflammatory bowel disease
		• Idiopathic
Struvite		
Magnesium-ammonium-phosphate	15-20%	• Urease-producing bacteria
Uric Acid	5-10%	• Gout
		• Myeloproliferative disorders
		• Inflammatory bowel disease
		• Idiopathic
Cystine	1%	• Inborn errors of metabolism

calculi, described for their appearance of a staghorn as the stone grows up through the calices from the renal pelvis. Prolonged antibiotic therapy has been proven ineffective because of poor penetration into the stones (which act as foreign bodies), necessitating surgical removal of many of these stones.[14]

Uric acid stones account for 5-10% of all stones and are caused by excess levels of uric acid in the urine. Because uric acid is a weak acid, it also becomes less soluble when the urine becomes more acidic (seen with excess intake of animal protein[15]), promoting sedimentation and formation of stones. Interestingly, 25% of patients suffering from gout have uric acid nephrolithiasis.[16] Currently there is limited objective data regarding dietary recommendations for patients suffering from uric acid nephrolithiasis; however, decreasing meat intake typically is suggested.

Cystine stones comprise only 1% of kidney stones. The disorder leading to cystine stone formation has been described as an autosomal recessive inborn error of metabolism that results in increased urinary excretion of cystine, lysine, arginine, and ornithine.[17] Unlike lysine, arginine, and ornithine, cystine has very low solubility in urine, and is further precipitated into solute by acidic, supersaturated urine. Patients with cystine stones usually present in the second or third decades of life. The stones are radiopaque and, like struvite stones, may form staghorn calculi.

History and Predisposing Factors

Certain historical factors are important in the evaluation of nephrolithiasis. Risk factors associated with nephrolithiasis should be sought, including previous history of nephrolithiasis, family history of nephrolithiasis, conditions resulting in urinary stasis (including anatomic abnormalities, prostatic hypertrophy), metabolic abnormalities, abnormal urine pH, recent urinary tract infection, low urine output, and environmental factors such as excessive heat resulting in dehydration, fluid restriction, or occupation. History of previous episodes of nephrolithiasis, previous stone size, previous interventions, and stone composition should be sought, if applicable. Numerous medications are associated with the development of nephrolithiasis. (*See Table 2.*) Medication-induced calculi have been estimated to represent 1-2% of all nephrolithiasis cases.[18] Medications may cause nephrolithiasis by several mechanisms. Some medications such as triamterene, indinavir, and sulfadiazine have poor solubility resulting in crystallization in the urine. Medications such as calcium or vitamin D supplements can cause calculi formation as a result of metabolic effects. Calculi formation also is influenced by urine output, urine pH, and other factors.

Physical Examination

The physical examination of patients with suspected nephrolithiasis should be focused on relevant examination features. Vital signs should be performed immediately, and patients with fever, hypotension, or tachycardia may require early intervention with fluid resuscitation. Other potential causes of flank pain should be addressed in the physical examination, including examination of the lung fields and thorough abdominal examination. Presence of costovertebral tenderness should be sought. Evidence of trauma should be evaluated. Assessment of pain should be performed for all patients to facilitate appropriate pain management.

Diagnostic Studies

Urinalysis. All patients presenting to the ED with complaints of flank or lower abdominal pain should undergo urinalysis. Those with urinary calculi often will exhibit microscopic hematuria; however, it has been shown that 7-12% of kidney stones may present without hematuria.[19] As previously discussed, urinary pH also is important in the formation of kidney stones, particularly cystine and uric acid stones, which have a tendency to form in more acidic environments. Conversely, struvite stones more often are seen with alkaline urine. The presence of leukocyte esterase, white blood cells, or nitrites on

Table 2. Medications Associated with Nephrolithiasis*

ANTACIDS
• Magnesium trisilicate
• Aluminum hydroxide
• Magnesium hydroxide
• Colloid silica
ANTIBACTERIAL AGENTS
• Sulfamethoxazole
• Sulfadiazine
• Amoxicillin
• Ampicillin
• Ceftriaxone
• Ciprofloxacin
• Norfloxacin
• Nitrofurantoin
PROTEASE INHIBITORS
• Indinavir
• Nelfinavir
ANTIHYPERTENSIVE AGENTS
• Triamterene
• Furosemide
OTHER MISCELLANEOUS AGENTS
• Calcium supplements (especially in conjunction with vitamin D therapy)
• Ascorbic acid
• Corticosteroids
• Methotrexate
• Guaifenesin
• Allopurinol
• Sulfasalazine

*This table provides a representative list, but is not inclusive of all medications implicated in association with nephrolithiasis.

urinalysis are suggestive of a concomitant urinary tract infection. If a urinary tract infection is suspected, urine culture should be sent. A limited amount of pyuria can exist; however, as stones cause an inflammatory response along the urinary tract.[20] Microscopic examination of the urine also may elucidate other findings, such as crystals that may aid in identification of the type of stone present.

Serum Studies. Some physicians recommend a complete blood count (CBC) with differential for patients with possible infection. Urosepsis in the presence of urinary tract obstruction is an indication for emergent urology consultation and intervention. Unfortunately, the CBC is not sensitive or specific in such cases, and demargination may occur simply from the pain associated with renal colic. More suspicious findings for sepsis would include a predominance of neutrophils or elevated bands on the differential. If a patient presents with complete obstruction in the presence of a UTI, a full septic workup including blood and urine cultures should be obtained.

Because the opposite kidney compensates for the affected kidney in urinary obstruction, the blood urea nitrogen (BUN) and creatinine typically are not elevated unless a single kidney or bilateral obstruction is present.[5] Electrolytes, BUN, and creatinine may aid in determining the etiology of disease in a patient (such as renal tubular acidosis), and may be required if a contrast study is needed to aid in the diagnosis.

Radiographic Evaluation

Patients with the first episode of nephrolithiasis should undergo radiographic evaluation to assess stone size and position, presence of hydronephrosis, obstruction, and renal function. Patients with recurrent nephrolithiasis may not require radiographic evaluation with every occurrence, and the emergency physician should judiciously order diagnostic tests based on clinical presentation, recent diagnostic evaluation, and likelihood of obstruction or hydronephrosis.

Plain Abdominal Radiograph (KUB). Because of its poor sensitivity, specificity, and inability to detect urinary obstruction or kidney dysfunction, the KUB is of limited value in the initial workup of acute flank pain due to kidney stones. In a recent retrospective study, abdominal radiography had a sensitivity of only 45% with a specificity of 77% in the acute workup of urinary tract stones.[21] These results improved to 59% and 71% respectively when two of the authors retrospectively reviewed the films of patients with known stone disease.[21] In patients undergoing conservative management for confirmed stone disease, the KUB serves as an excellent imaging tool for monitoring stone progression.

Intravenous Pyelogram (IVP) vs. Noncontrast Helical Computerized Tomography (NHCT). The IVP once was accepted as the test of choice for the initial evaluation of flank pain from suspected kidney stones. This has changed because of the increased sensitivity, specificity, speed of testing, and the ability to identify other etiologies of abdominal or flank pain with NHCT. NHCT also will identify most radiolucent kidney stones, the size of the stones, and eliminates exposure to IV contrast and its complications. A recent meta-analysis pooled data from four studies comparing NHCT with IVP and showed NHCT (sensitivity 94-100%, specificity 92-100%) to be unanimously more accurate than IVP (sensitivity 52-87%, specificity 92-94%) in the evaluation of kidney stones.[22]

IVP accurately characterizes the degree of ureteral obstruction, kidney function, and important anatomic anomalies in the collecting system, all of which may be helpful to the urologist for determination of definitive therapy. NHCT does not provide direct functional information, but often function and the degree of obstruction can be postulated using secondary signs of hydronephrosis such as perinephric stranding, ureteric dilatation, kidney size, and forniceal rupture. These secondary signs can also be used for diagnosis of kidney stones when the stone itself is not visible or an indefinite calcification is identified.[23] The presence and severity of these secondary findings, however, play no role in determination of conservative versus interventional therapy.[24] Boulay et al. claimed that stone size was the only

parameter that correlated with the type of definitive therapy a patient would receive.[24] This suggests NHCT alone is adequate for the diagnosis and treatment of kidney stones in patients with normal anatomy.

NHCT has some disadvantages, however. First, NHCT requires the patient be exposed to radiation doses approximately three times higher than that of IVP.[25] This has especially high implications in patients with repeated bouts of flank pain due to higher stone burden or malingering. Interestingly, a recently published article suggests that there is no difference in the diagnostic accuracy for reduced dose NHCT using reduced tube current.[26] One may consider other imaging modalities such as ultrasound or magnetic resonance imaging (MRI) in children or the pregnant patient.

Second, there has been controversy over the total cost of NHCT vs. IVP. Contrary to previous studies suggesting no difference in the charges (what the patient is billed) between NHCT and IVP, Li et al. claim that IVP is one quarter the price of NHCT.[19] However, when considering the indirect costs such as length of stay, manpower utilization, and additional testing in cases with vague results, IVP ultimately may prove to be more expensive.[27,28]

Ultrasound. Previous studies have concluded that ultrasound has consistently low sensitivity for detection of urinary calculi (37-64%).[29-33] Bedside ultrasound performed by the emergency physician to detect hydronephrosis also has had low sensitivity and specificity in prediction of kidney stones (72% and 73%, respectively).[34] Ultrasound can be useful in select patients in whom radiation exposure should be avoided (pediatric and pregnant patients) despite its poor performance.[31] Ultrasound yield also may vary depending on operator experience, body habitus, and presence of bowel gas and adjacent bone structures. These findings support the use of NHCT as the primary imaging tool for flank pain in the ED.

Magnetic Resonance Imaging (MRI). MRI, or more specifically, magnetic resonance urography (MRU) has been studied for evaluation of patients with acute ureteral obstruction. The major advantages of MRU are elimination of radiation exposure, enhanced identification of extrarenal causes of obstruction (such as neoplasm or hematoma), and the ability to accurately relay information about the structure and function of the urinary tract.

MRU alone, or in combination with targeted NHCT, has been proven effective in the workup of acute ureteral obstruction.[35,36] A recent study revealed comparable sensitivity and specificity of MRU (93.8-100% and 100%, respectively) when compared with NHCT.[37] Unfortunately, MRU is poor in identification of calcifications as they result in a signal void, hindering the direct identification of a ureteral stone. The presence of stones is assumed when a filling defect with signs of obstruction are present in the ureteral lumen. Such findings most frequently are due to the presence of a stone, but neoplasm or blood clots also may present this way.[38] Because MRU does not directly characterize the stone, NHCT is more accurate in measuring stone size, the most important determinant of conservative versus interventional therapy.[24,38] Other drawbacks to MRU are higher costs, longer testing time leading to delayed diagnoses, and the limited availability in most EDs. This limits use of MRU to patients more sensitive to radiation exposure.

Table 3. Differential Diagnosis of Nephrolithiasis

Possible alternative diagnoses to consider in the differential for kidney stones include:

- Abdominal aortic aneurysm
- Renal trauma
- Renal infarction
- Pyelonephritis
- Renal malignancy
- Papillary necrosis
- Retroperitoneal infection or hematoma
- Pneumonia
- Gall bladder disease
- Splenic disease
- Ovarian pathology
- Testicular torsion
- Appendicitis
- Hernia
- Other intraabdominal emergencies resulting in flank pain

Stone Analysis

For all patients with nephrolithiasis, stone analysis is indicated. A stone that has passed in the ED should be sent to the lab for classification. Patients who are discharged from the ED should be instructed to strain all urine and collect stones for analysis.

For patients with repeat episodes of nephrolithiasis, 24-hour urine collection is indicated. Although this is not typically initiated in the ED, it may be helpful to instruct patients about these likely diagnostic tests.

Differential Diagnosis

When considering the diagnosis of nephrolithiasis, the emergency physician should also consider alternative possible diagnoses. Perhaps the most life-threatening diagnosis to consider is abdominal aortic aneurysm, which may present with flank pain. Age, syncope, and hypotension may increase the likelihood of abdominal aortic aneurysm. Other diagnoses to consider include renal trauma, renal infarction, pyelonephritis, renal malignancy, papillary necrosis, retroperitoneal infection or hematoma, pneumonia, gall bladder disease, splenic disease, ovarian pathology, testicular torsion, appendicitis, hernia, and other intraabdominal emergencies resulting in flank pain. (*See Table 3.*)

Emergency Department Management

Analgesia. Prompt attention should be directed toward pain management in patients presenting with presumed ureteral colic. It is thought that pain from ureteral colic is due to ureteric muscle spasm provoked by the presence of a kidney stone. Further pain arises from obstruction caused by the stone with resulting distention of the ureters and renal pelvis. Prostaglandins then are

released, stimulating stronger ureteric contractions and dilatation of the afferent arterioles leading to an increased glomerular filtration rate and even higher renal pelvis pressures. Understanding of this physiology has sparked studies for a multitude of analgesics for use in ureteral colic, including narcotics, nonsteroidal anti-inflammatory drugs (NSAIDs), calcium channel blockers, anticholinergics, and vasopressin analogues.

Nifedipine is a calcium channel blocker that inhibits human ureteric smooth muscle in vitro. Unfortunately, nifedipine was found to have no analgesic efficacy in the treatment of acute ureteral colic.[39] Likewise, a recent study of the antispasmodic properties of sublingual hyoscyamine sulfate (an anticholinergic) in combination with ketorolac for use in renal colic found no difference in the level of pain relief as compared to ketorolac alone.[40] Intranasal desmopressin, a vasopressin analogue, has been found somewhat effective alone or in combination with NSAIDs for the treatment of ureteral colic.[41,42] These were very small studies, however, and further research is needed before more reliable conclusions can be drawn. Desmopressin is thought to work by decreasing diuresis, relaxing smooth muscle, and stimulating endorphin release centrally.[42] Advantages to intranasal desmopressin include ease of administration and lack of clinically significant side effects.

Narcotics have long been the mainstay for achieving adequate analgesia in acute ureteral colic in the United States. However, NSAIDs have been used for decades in other countries for analgesia in ureteral colic with great success. Researchers pooled data from 19 studies and found the analgesic properties of NSAIDs to be equally as efficacious as opioids and other analgesics in ureteral colic.[43] NSAIDs block synthesis of prostaglandins and their deleterious effects on the urinary tract during acute ureteral obstruction, as described above. Ketorolac is the only NSAID available for intravenous or intramuscular administration in the United States. Ketorolac recently has gained popularity for the treatment of ureteral colic despite a general lack of larger prospective blinded studies comparing its efficacy against opioids. Smaller studies have suggested significantly better analgesia using one 60-mg dose of ketorolac intravenously or intramuscularly alone versus meperidine alone.[44,45] Despite the small size of these studies, results have been quite striking and suggest NSAIDs be used as a first line analgesic agent in the treatment of acute ureteral colic. Opioids may be used for rescue therapy in those with persistent pain, though combination therapy with ketorolac and meperidine appears no more efficacious than ketorolac alone.[44]

Antibiotics. Patients suspected to have an underlying urinary tract infection (UTI) with presence of ureteral obstruction require immediate intravenous antibiotics and emergent urology consultation. Initial choices should cover the typical Gram negative species, but also Enterobacteriaceae, *P. aeruginosa*, and enterococci. Appropriate antibiotics may include ampicillin plus gentamycin, piperacillin/tazobactam, ticarcillin/clavulanic acid, imipenem, meropenem, or a fluoroquinolone.[46] There is obvious risk for developing severe sepsis and permanent renal damage when ureteral obstruction coincides with infection, so early antibiotic administration is essential.

Prevention of Nephrolithiasis

Diet and Hydration. Though aggressive fluid hydration has been used as a means of stone passage in the past, there is no evidence that this is of benefit while in the ED. Peristalsis of the ureter appears to be the driving mechanism behind stone passage. However, because recurrence of stone disease is common, increased long-term fluid intake should be recommended to all patients. The benefit of increased fluid intake has been well documented and effectively lowers the concentration of urine and resultant kidney stone formation.[48] The patient should be advised to maintain sufficient fluid intake to produce two liters of urine per day.[47] This is simple for the ED physician to recommend, but compliance typically is very poor.[48]

Low calcium diets historically have been recommended to patients with recurrent kidney stones. However, calcium restriction has been associated with reduced intestinal absorption, resulting in higher excretion of oxalate in the urine, associated with higher rates of stone formation.[49-51] Currently, most experts recommend normal calcium intake.[51-54] Many other dietary modifications have been recommended by some authors, including reduced intake of protein, sodium, and simple sugars.[55,56] For patients with hyperoxaluria, reduced intake of foods high in oxalate is recommended (such as rhubarb, black tea, and spinach).

Maintenance of appropriate weight, or weight loss, if indicated, may be of benefit in prevention of recurrent nephrolithiasis.[57]

Preventive medications may be indicated for certain patients with nephrolithiasis. Thiazine and chlorthalidone may be effective in the prevention of nephrolithiasis for patients with recurrent calcium oxalate stone formation.[58] Allopurinol may be indicated for patients with hyperuricosuria; however, therapeutic benefit may be limited to long-term use (more than 12 months). Potassium-magnesium citrate has been shown to reduce incidence or repeat nephrolithiasis in patients with calcium oxalate nephrolithiasis.[49]

Special Patient Populations

Pediatrics. Nephrolithiasis may occur in pediatric patients. Management is unchanged from that of adult patients. Appropriate diagnostic studies should be undertaken to assess stone size and position. To minimize radiation exposure, ultrasound or MRI may be preferred over NHCT. Stone composition should be determined for first-time stones, and 24-hour urine collection should be obtained for recurrent stones. Appropriate management includes pain control, hydration, and urologic follow-up. Complications such as infection, dehydration, intractable pain or vomiting, or anatomic abnormality may be indications for hospital admission and emergent urologic consultation.

Pregnancy. Nephrolithiais may occur during pregnancy, with an incidence of approximately one out of 1500 pregnancies, similar to the incidence for nonpregnant females.[59] To minimize radiation exposure, the diagnostic test of choice is ultrasound. Alternative diagnostic studies may include MRI or limited intravenous urograms. The majority of pregnant patients (70-80%) with nephrolithiasis will pass stones spontaneously with supportive care and expectant management. If intervention is necessary, internal stents or percutaneous nephrostomy tubes may be appropriate.

Table 4. Management Summary

ANALGESIA

Ketorolac 30-60 mg IV unless otherwise contraindicated.
Opioids for balanced analgesia or breakthrough pain as needed

LABS

All patients should have a urinalysis performed. A complete septic workup, including blood and urine cultures, should be done on all patients who present with complete obstruction and signs of a urinary tract infection.

IMAGING

NHCT
Consider ultrasound or MRU in children or pregnant patients.

ANTIBIOTICS

Administer early in patients who appear septic or have signs of complete obstruction on NHCT or IVP. If no obstruction or partial obstruction exists with signs of a urinary tract infection, oral antibiotics may be appropriate in consultation with a urologist.

EDUCATION

Advise increased fluid intake to make approximately 2 liters of urine per day or to keep the urine clear. Provide urine filter to collect stones for further analysis.

DISPOSITION

Immediate consultation with urology for those patients who are septic with complete obstruction. Patients who are nontoxic may be sent home with appropriate analgesia, a urine strainer, and instructions to follow up with a urologist.

Malingering. Unfortunately, there are certain patients who may attempt to feign symptoms of nephrolithiasis with the objective of obtaining pain medication. Some patients have gone to lengths, such as pricking a finger to introduce a drop of blood into the urine sample to mimic hematuria. If such behavior is suspected, obtaining a witnessed urine sample may be of value. Medical records should be referenced, and previous similar history should be sought. However, such past behavior does not definitively rule out nephrolithiasis, and all patients should be appropriately evaluated with discretionary diagnostic studies to confirm or refute the diagnosis of nephrolithiasis.

Disposition and Consultation

Most patients with nephrolithiasis can be appropriately discharged home with analgesia and instructions for follow-up. Oral NSAIDs should be continued at home, and oral opioids such as hydrocodone/acetaminophen or oxycodone/acetaminophen may be prescribed as needed for breakthrough pain.

As noted above, patients should be instructed to increase general fluid intake to ensure approximately two liters of urine output per day (or to maintain clear urine). Patients also should be instructed to strain their urine with strainers provided in the ED so the stone composition may be determined. The patient should have instructions to return to the ED immediately if he/she experiences uncontrolled pain, fever, chills, or vomiting. Follow-up with a urologist should be scheduled within 1-2 weeks.

Indications for admission include intractable pain or vomiting, UTI with obstruction, transplanted or single kidney with obstruction, or uncertainty about the diagnosis. The emergent nature of UTI in the face of obstruction has already been stressed, and many of these patients will require immediate surgical decompression to allow the antibiotics to better reach the affected site by means of improved urine excretion. UTIs with concomitant kidney stones and no obstruction may be safely discharged on an oral fluoroquinolone with urologic follow-up scheduled within 24 hours. (*See Table 4 for Management Summary.*) Because of the significant risk for renal failure in a patient with only one kidney and urinary obstruction, earlier surgical intervention may be required and a urologist should be involved early in the course. Finally, if no stone is positively identified and significant abdominal pain persists, the patient should be observed for improvement or deterioration, as with other abdominal pain of uncertain etiology.

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Physician CME Questions

191. A 36-year-old man is found to have a 3 mm stone in the left ureterovesicular junction. He is reassured that the stone likely will pass on its own. He asks if he is at risk for recurrent episodes in the future. You tell him:
    A. No risk factors predict recurrent nephrolithiasis.
    B. Because the stone is small and he has no family history of kidney stones, recurrent disease is unlikely.
    C. He has a 50% chance of a repeat episode within 10 years.
    D. Diet and fluid intake do not affect recurrence rate.
    E. The location of the stone predicts recurrence rate.

192. A 40-year-old male presents with acute flank pain and signs of partial obstruction around a 5 mm kidney stone in the left ureter on NHCT. He is afebrile, appears nontoxic, and his urinalysis is negative for nitrite and leukocyte esterase. His pain is controlled in the ED. What is the most appropriate course of action?
    A. Discharge the patient home with appropriate analgesia, a urine strainer, and follow-up with a urologist within 1-2 weeks.
    B. Obtain emergent urology consultation.
    C. Admit the patient with aggressive IV fluid hydration and IV antibiotics.
    D. Schedule an immediate MRI to rule out mass or hematoma.
    E. Admit the patient for ureteral stent placement.

193. A 28-year-old woman presents to the ED with severe right-sided flank pain. She is 12 weeks pregnant and has a family history of kidney stones. What is the most appropriate management plan?
    A. Schedule an emergent MRI and control her pain.
    B. Control her pain, get an immediate ultrasound, start IV antibiotics.
    C. Control her pain, check a urinalysis, get an ultrasound to rule out other etiologies for her flank pain, and schedule an MRI for the morning if no stone is identified on ultrasound.
    D. Discharge home with analgesics and schedule follow-up with her obstetrician.
    E. Control her pain and obtain an NHCT.

194. Which of the following statements is true regarding MRI used in the workup of acute flank pain?
    A. MRI gives increased radiation exposure compared to NHCT.
    B. MRI provides improved identification of extrarenal causes of obstruction.
    C. MRI has reduced ability to identify structure and function of the urinary tract.
    D. It is contraindicated in pregnancy.
    E. It has a risk of dye-induced nephropathy.

195. What is the most appropriate first-line analgesic for a patient with acute renal colic caused by nephrolithiasis?
    A. Morphine sulfate
    B. Meperidine
    C. Ketorolac
    D. Nifedipine

196. What percentage of patients with gout will have uric acid nephrolithiasis?
    A. 10%
    B. 25%

Emergency Medicine Reports CME Objectives

To help physicians:

- quickly recognize or increase index of suspicion for specific conditions;
- understand the epidemiology, etiology, pathophysiology, and clinical features of the entity discussed;
- apply state-of-the-art diagnostic and therapeutic techniques (including the implications of pharmaceutical therapy discussed) to patients with the particular medical problems discussed;
- understand the differential diagnosis of the entity discussed;
- understand both likely and rare complications that may occur.

CME Instructions

Physicians participate in this continuing medical education program by reading the article, using the provided references for further research, and studying the questions at the end of the article. Participants should select what they believe to be the correct answers, then refer to the list of correct answers to evaluate their knowledge. To clarify confusion surrounding any questions answered incorrectly, please consult the source material. *After completing this activity, you must complete the evaluation form that will be provided at the end of the semester and return it in the reply envelope provided to receive a certificate of completion.* When your evaluation is received, a certificate will be mailed to you.

C. 50%
D. 75%

197. What approximate percentage of patients presenting with acute renal colic from kidney stones will *not* show microscopic hematuria on urinalysis?
A. 10%
B. 25%
C. 50%
D. 75%
E. 90%

198. For which of the following patients should an emergent urology consult be obtained?
A. A 33-year-old pregnant woman with severe flank pain
B. A 29-year-old man with a 3 mm stone in the proximal ureter and partial obstruction
C. A 65-year-old woman with a temperature of 39.0°C and complete obstruction of the left ureter from an 8 mm kidney stone
D. A 12-year-old female with a 4mm kidney stone in the right

199. Which of the following may be frequently associated with nephrolithiasis?
A. Azithromycin
B . AZT
C. Ethyl alcohol
D. Phenytoin
E. Sulfamethoxazole

200. Which type of kidney stone occurs most frequently?
A. Magnesium-ammonium phosphate
B. Uric acid
C. Cystine
D. Sodium chloride
E. Calcium oxalate

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In Future Issues: Pertussis

CME Answer Key

191. C	196. B
192. A	197. A
193. C	198. C
194. B	199. E
195. C	200. E

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Nephrolithiasis

Stone Types

STONE TYPE	FREQUENCY	COMMON CAUSES
Calcium Calcium oxalate Calcium phosphate Mixed	70-80%	• Hypercalciuria • Hyperparathyroidism • Renal tubular acidosis • Inflammatory bowel disease • Idiopathic
Struvite Magnesium-ammonium-phosphate	15-20%	• Urease-producing bacteria
Uric Acid	5-10%	• Gout • Myeloproliferative disorders • Inflammatory bowel disease • Idiopathic
Cystine	1%	• Inborn errors of metabolism

Medications Associated with Nephrolithiasis

ANTACIDS
- Magnesium trisilicate
- Aluminum hydroxide
- Magnesium hydroxide
- Colloid silica

ANTIBACTERIAL AGENTS
- Sulfamethoxazole
- Sulfadiazine
- Amoxicillin
- Ampicillin
- Ceftriaxone
- Ciprofloxacin
- Norfloxacin
- Nitrofurantoin

PROTEASE INHIBITORS
- Indinavir
- Nelfinavir

ANTIHYPERTENSIVE AGENTS
- Triamterene
- Furosemide

OTHER MISCELLANEOUS AGENTS
- Calcium supplements (especially in conjunction with vitamin D therapy)
- Ascorbic acid
- Corticosteroids
- Methotrexate
- Guaifenesin
- Allopurinol
- Sulfasalazine

*This table provides a representative list, but is not inclusive of all medications implicated in association with nephrolithiasis.

Management Summary

ANALGESIA
Ketorolac 30-60 mg IV unless otherwise contraindicated.
Opioids for balanced analgesia or breakthrough pain as needed

LABS
All patients should have a urinalysis performed. A complete septic workup, including blood and urine cultures, should be done on all patients who present with complete obstruction and signs of a urinary tract infection.

IMAGING
NHCT
Consider ultrasound or MRU in children or pregnant patients.

ANTIBIOTICS
Administer early in patients who appear septic or have signs of complete obstruction on NHCT or IVP. If no obstruction or partial obstruction exists with signs of a urinary tract infection, oral antibiotics may be appropriate in consultation with a urologist.

EDUCATION
Advise increased fluid intake to make approximately 2 liters of urine per day or to keep the urine clear. Provide urine filter to collect stones for further analysis.

DISPOSITION
Immediate consultation with urology for those patients who are septic with complete obstruction. Patients who are nontoxic may be sent home with appropriate analgesia, a urine strainer, and instructions to follow up with a urologist.

Differential Diagnosis of Nephrolithiasis

Possible alternative diagnoses to consider in the differential for kidney stones include:
- Abdominal aortic aneurysm
- Renal trauma
- Renal infarction
- Pyelonephritis
- Renal malignancy
- Papillary necrosis
- Retroperitoneal infection or hematoma
- Pneumonia
- Gall bladder disease
- Splenic disease
- Ovarian pathology
- Testicular torsion
- Appendicitis
- Hernia
- Other intraabdominal emergencies resulting in flank pain

Supplement to *Emergency Medicine Reports*, September 19, 2005: "Nephrolithiasis: Diagnosis and Management in the Emergency Department." *Authors:* **Catherine Marco, MD, FACEP,** Clinical Professor, Department of Surgery, Division of Emergency Medicine, Medical College of Ohio; Attending Physician, St. Vincent Mercy Medical Center, Toledo, OH; and **Brock Boscovich, MD**, Resident, Emergency Medicine Residency, St. Vincent Mercy Medical Center, Toledo, OH.