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Rising prevalence of renal calculi: Treatments and considerations

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Abstract: Severe pain and urinary tract obstruction are hallmarks of renal calculi often requiring hospitalization and treatment. Renal damage can occur without proper intervention. This article discusses the role of nurses in caring for patients with renal calculi, current treatment approaches, and prevention strategies.

Keywords: kidney stone disease, nephrolithiasis, renal calculi

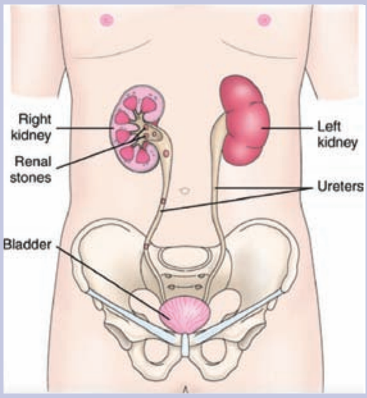
Case study

DH, a 70-year-old White male, accompanied by his son, arrived at the ED with complaints of excruciating left flank pain. DH was awake, alert, and oriented. He was visibly uncomfortable and grimacing with slight facial diaphoresis. DH stated that the pain started 24 hours prior while driving home after a long weekend of camping and hiking in Colorado. He described his pain as 10/0-10, sharp, nonradiating, and that nothing relieves or exacerbates the pain. "I cannot imagine anything making it hurt worse than it does," stated DH.

DH has a history of urinary tract infections and renal calculi. He has no known allergies and does not take any prescription or over-the-counter (OTC) medications except OTC multivitamins.

DH recently started a low-carbohydrate/high-protein diet and exercise program. His last bowel movement was the previous night and it was formed and brown. His last urination was on the morning of his arrival, light amber in color, painful, and malodorous. "It was less than the normal amount for when I first wake up," he said. When asked about how much water he drank the previous weekend, he stated he tries but does not like the taste of water alone and usually drinks unsweetened iced tea.

Renal calculi



DH's abdomen was flat with normal active bowel sounds. Guarding was present during palpation, especially in the left upper quadrant and left flank; no masses were noted.

The nurse placed a large-bore I.V. access and collected blood specimens for lab tests. The nurse provided instructions and supplies for a clean catch urine sample and information about the ordered computed tomography (CT) scan of his abdomen.

DH's bloodwork results were all within normal limits. Urinalysis showed the presence of bacteria, leukocytes, nitrates, red blood cells, and elevated specific gravity. CT of the abdomen demonstrated a radiopaque, 10 mm staghorn stone in the left ureter with hydronephrosis.

DH received the nonsteroidal anti-inflammatory drug (NSAID) I.V. ketorolac and the quinolone antibiotic, ciprofloxacin pending urine culture results. A referral for a urologist consultation was initiated for possible surgical intervention based on the type and size of the renal calculus. DH also received education concerning urinary tract infection (UTI) and renal calculi prevention, new medications, and what to expect from the urology consultation.

Renal calculi, also known as kidney stone disease or nephrolithiasis, have become progressively problematic worldwide.

The clinical and economic burden of renal calculi in the United States is evident. Data based on the 2017-2018 National Health and Nutrition Examination Survey estimates prevalence at 11.9% in men and 9.4% in women.[1] Rates among men over 20 years of age remained relatively unchanged since 2007; however, an almost 3% increase was observed in women aged 20-60 over the same time period.[1] Hospitalizations, treatment, and prevention strategies have increased costs as prevalence has continued to rise.[2]

Risk factors

Factors related to increased incidence of calculi formation include age, ethnicity, gender, geography, environmental factors, metabolic disorders, and lifestyle.[3] Data suggests the highest prevalence of renal calculi in the United States is in non-Hispanic White individuals, and to a lesser extent in Hispanic and non-Hispanic Black individuals.[4] Historically, the incidence in men has exceeded that of women; however, this difference continues to narrow.[1]

North America has the highest incidence of calculi formation, followed by Europe and Asia, respectively. Globally, prevalence has increased in men and women.[5] Environmental factors such as high temperatures and sun exposure are thought to affect water and electrolyte balances within the body, causing an increased risk of renal calculi formation.[3] Lifestyle factors that play a significant role in renal calculi formation include a diet high in sodium or calcium; high in protein and low in carbohydrates or high on the dietary inflammatory index; decreased water intake; sedentary lifestyle; and obesity.[6,7] Metabolic disorders such as diabetes and the metabolic syndrome result in hypercalciuria, hyperoxaluria, hyperuricosuria, and hypocitraturia (see *Health disorders associated with renal calculi*). The presence of such metabolic alterations increases the risk of renal calculi formation.[3,8]

Pathophysiology

Supersaturation of urine is present in the development of renal calculi.[9,10] Supersaturation occurs when substances in urine are no longer soluble.[9] Concentrated substances in supersaturated urine form crystals that then attach to the urothelium, creating a nidus or a focal point for the attachment of other crystals.[10] Renal calculi vary in composition. The majority of renal calculi that form in the urinary tract are calcium-based, with approximately 70-80% comprised of calcium oxalate and 15% calcium phosphate.[11] Other renal calculi are made from uric acid (8%), cystine (1-2%), and struvite (1%).[11] A small number of iatrogenic calculi can also form in the urinary tract due to certain insoluble drugs, such as topiramate, acetazolamide, and long-term glucocorticoids.[11]

Clinical manifestations

Many patients will remain asymptomatic until renal calculi travel from the renal pelvis downward through the ureters and into the bladder (see *Renal calculi*). Flank pain, which can radiate to the groin, is frequently the

Health disorders associated with renal calculi

- Hyperparathyroidism
- Sarcoidosis
- Bone disease
- Immobilization
- Hyperthyroidism
- Distal renal tubular acidosis
- Polycystic kidney disease
- Chronic pancreatitis
- Bowel resection
- Cystic fibrosis
- Primary hyperoxaluria
- Gout
- Metabolic syndrome
- Obesity
- Diabetes
- Chronic kidney disease
- Renal cystine reabsorption defects

first noticeable symptom.[9] Severe pain, also known as renal colic, along with nausea and vomiting, results from ureteral spasms and swelling of the kidney secondary to the obstructed urine flow created by the calculus.[12,13] Obstruction may lead to urinary urgency and frequency with the onset of dysuria as a calculus travels down the ureter to the bladder. Hematuria may result from small tears created by the movement of a jagged calculus through the ureter and bladder.[9] Signs and symptoms of infection may also accompany renal calculi.

Diagnostic studies

Lab testing associated with the onset of renal calculi includes urinalysis to assess for hematuria, urine culture if an infection is suspected, and a basic metabolic profile to assess kidney function and electrolyte balance.[14] More specific testing for patients with recurrent calculi may include a 24-hour urine collection.[14]

Radiologic imaging assists in identifying the location, size, and shape of the renal calculus, which is essential when exploring treatment options.

Non-contrast-enhanced computed tomography (CT) has become the standard diagnostic tool for renal calculi and assists with assessing the burden, and classification by density and composition. Low-dose CT has a lower risk profile and may be appropriate for patients with a body mass index greater than 30 kg/m^2.[15] If CT technology is not available, ultrasound (US) of the kidneys and bladder, sometimes in combination with abdominopelvic radiography, is the second-line option for initial imaging. US often fails to detect calculi in the ureters.[15] Kidney-ureter-bladder (KUB) images assist in differentiating between radiolucent and radiopaque calculi and provide a baseline for future comparison.[15,16] CT-KUB imaging limits the radiation field from the kidney to the urethra, which is particularly relevant to young patients with risk for recurrent renal calculi formation and need for future imaging.[16] Radiologic imaging is required for the assessment of calculi burden. Although routinely used, the American College of Emergency Physicians does not recommend a CT scan for individuals under 50 years old with recurrent renal calculi who present with typical renal colic uncomplicated by other signs or symptoms.[17]

Preventive measures for all stone types

- Sufficient fluid (water is recommended) intake to consistently produce at least 2 L of urine per day
- Decreased dietary sodium intake to below 2,300 mg per day
- Increased dietary fruit and vegetable intake
- Weight loss

Source: www.uptodate.com/contents/kidney-stones-in-adults-prevention-of-recurrent-kidney-stones?search=kidney%20stone%20prevention&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1#H2759385697

Initial management

Nursing interventions include performing a focused abdominal assessment, placing a 20 gauge or larger I.V. access, providing analgesia and other medications as prescribed, and collecting specimens for blood tests and urinalysis. Following diagnostic evaluation, patient education and coordination of care continue.

Initial medical management of patients with renal calculi addresses four primary areas: pain management, lab testing, radiologic imaging, and I.V. fluids. Once the renal calculus is confirmed, the care plan with treatment options can be discussed with the patient.

Pain management is a priority intervention. The most effective medications include NSAIDs such as ketorolac and ibuprofen unless previous kidney disease is present.[18,19] Note that to relieve acute pain, the I.V. form is the quickest acting. The oral forms of ketorolac and ibuprofen can be given for ongoing pain. NSAIDs have greater analgesic efficacy than opioids when treating the pain associated with renal calculi.[19,20]

I.V. fluid administration, a controversial intervention, assists renal calculus passage by increasing the volume of urine output. However, increased pressure from higher urine output could also accentuate the pain.[21] Conservatively, patients with dehydration or who will be undergoing invasive procedures as a treatment for their renal calculi may receive I.V. fluid.[21] A review of the patient's health history before I.V. fluid initiation identifies patients with risk for fluid overload such as patients with heart failure.

Understanding the composition of renal calculi is vital in educating the patient on prevention. If a calculus is available, an analysis should occur. If a calculus consists of uric acid, cystine, or struvite, a metabolic or genetic root cause is suspect and should be considered.[22] However, general prevention guidelines apply to all types of renal calculi (see *Preventive measures for all stone types*).

Screening involves a detailed health and diet history, medication and supplement review, serum chemistries, and urine dipstick and urinalysis. Relevant findings include calcium intake below or significantly above recommended dietary allowance; high sodium and animal protein intake; and low intake of fluid, fruits, and vegetables.[14,22]

Metabolic disorders in those with the initial onset of renal calculi require further studies. Urologists recommend collecting one or two 24-hour urine samples obtained on a random diet to compare metabolic substances in the blood and urine. Experts prefer two collections with analysis for total volume, pH, calcium, oxalate, uric acid, citrate, sodium, potassium, and creatinine.[22]

Current treatment options

Renal calculi equal to or less than 4 mm usually pass spontaneously from the urinary system within 40 days.[23] Medical expulsive therapy (MET)—medication-aided calculi management with alpha-blockers, calcium channel blockers, or antispasmodic agents—increases the chance of passing a calculus with less pain.[24,25] All urine must be strained through a medical-grade filter to capture the calculi.

Calculi greater than 6 mm, or smaller calculi that do not respond to MET within 4-6 weeks, require a different approach.[26] When MET is not optimal, ongoing attempts involve noninvasively breaking up the calculus; accessing the calculus through the introduction of a scope via the urinary meatus; and surgical intervention.

Extracorporeal shock-wave lithotripsy (ESWL) is the most common treatment for renal calculi in the United States.[27] Sound waves from outside the body target the calculus to break it into fragments small enough to pass. ESWL has minor morbidity and complication rates; however, ESWL often requires repeated treatment sessions and is associated with steinstrasse formation in which smaller calculus fragments align and block the ureter as they exit the kidney toward the bladder.[28] Transient hematuria is common after ESWL but typically resolves within days. Major complications such as sepsis and hemorrhage are rare and occur in less than 1%.

Ureteroscopy (URS) involves passing a flexible scope through the urethral meatus, allowing providers to visualize the internal structures of the urinary collection system. Once located, a small basket retrieval device inside the scope allows for retrieving and removing whole or partial calculi. URS eliminates all calculi in a single treatment more often than ESWL.[28-30] URS is an appropriate intervention for calculi located in the mid- to lower-ureter and bladder.

URS and laser lithotripsy allow for breakage and removal of calculi larger than 2 cm with low complication rates, in many cases providing an alternative to surgical incision.[31] Laser lithotripsy can break the calculus into smaller pieces for retrieval through standard URS. It is also used to break the calculus into fine, dust-like particles (dusting), which will pass spontaneously with urination.

Stent placement is the temporary placement of a tiny tube in the ureter between the kidney and the bladder during URS.[30] Double-J stents are commonly used to keep the ureter open and facilitate urine flow. The stent consists of a flexible polyurethane or silicone catheter that coils in a circle on each end—one "J" curl lies in the renal pelvis; the other lies in the bladder with the length of the ureter catheterized in between.[32] The stent by-passes calculi to allow for the passage of urine.[33] Patients report variable discomfort while a stent is present.

Retrograde intrarenal surgery (RIRS) allows manipulation and removal of calculi from the upper ureter and kidney through a tube and scope introduced into the urinary system through the urethra.[30] In 2016, a randomized trial compared the treatment of renal calculi less than 2 cm with SWL to RIRS. In participants treated with RIRS, urologists assessed and removed calculi, as above, while participants in the SWL arm were treated and observed for calculus passage. Analysis of data from the two groups found the calculus-free rate 1 month after a single treatment session was greater in the RIRS group than the SWL group (90% versus 75%, P value = .03). Also, the RIRS group reported lower levels of postoperative pain compared with the SWL group (P value < .001).[28]

Percutaneous nephrolithotomy (PCNL) accesses calculi through a tract from a small incision in the back or flank to the obstructed kidney.[30] Laser treatment to break calculi may also be used. PCNL is now the preferred treatment for renal calculi greater than 20 mm and staghorn calculi, which consist of struvite. The risks associated with PCNL include puncture of a kidney without hydronephrosis, the requirement of multiple tracts to reach the various calyces containing calculi, and potential migration of calculi into the ureter.[34] PCNL carries a higher risk for persons with pregnancy, bleeding disorders, and uncontrolled urinary tract infections.[35]

Endoscopic combined intrarenal surgery (ECIRS), a combination of PCNL and URS, provides access to the calculi through the bladder and ureter and percutaneous access from an operating sheath inserted into the kidney. Laser lithotripsy occurs from the percutaneous access; irrigation and removal of calculus fragments by URS occur by flushing debris out through the tract.[30,34,36]

ECIRS with miniature percutaneous tract (Mini-perc) employs the benefit of ECIRS, but with smaller tracts and visualization of the urinary structures in real time.[36] Real-time virtual sonography (RVS) is accomplished with a system allowing simultaneous viewing of US images and preoperative CT images on a single monitor. A study in 2017 compared two groups receiving ECIRS: one with RVS, the other with US. Fewer attempts to puncture the calyx for renal access were required (1.6 versus 3.4 times, respectively; P = .001).[36] The visibility of arterial and venous circulation of the kidney via the dual imaging modalities resulted in a lower mean postoperative hemoglobin decrease (0.93 versus 1.39 g/dL, respectively; $P = .04$). The RVS group experienced no postoperative complications compared with patients in the US group.[33]

Postprocedure nursing considerations

Interventions and subsequent passage of renal calculi traumatize delicate, narrow passages. Post procedure, the nurse assesses pain-intensity level, fluid intake, and urine output, as well as urine characteristics. All urine must be strained. Transient hematuria is expected and may persist for days.

Pharmacotherapy considerations

Pharmacotherapy may include a thiazide diuretic for hypercalciuria but may require potassium supplementation; therefore, serum electrolyte results need to be monitored. In some instances, potassium citrate can address multiple issues including hyperuricosuria, hypocitraturia, and uric acid stone formation due to persistently acidic urine. Allopurinol is not reserved only for hyperuricosuria.[22] Allopurinol reduced the risk of recurrent calcium oxalate calculi when high uric acid and normal calcium levels are present in urine.[22] Recurrent renal colic can be reduced with the daily use of alpha-blockers.[15,16,24]

Patient education

Nursing considerations for patients with renal calculi include prevention and follow-up education. Preventing renal calculi is a priority because of the renal and ureteral trauma they can cause, and the financial burden of diagnosis and treatment. Following the Quadruple Aim of healthcare, renal calculi prevention improves the patient and clinician experience, decreases healthcare costs, and improves population health.[37] Education for the prevention of future renal calculi includes daily water intake of 2.0-2.5 L unless contraindicated, limiting sodium and nondairy animal protein, increasing activity to decrease the risk of metabolic disorders, and controlling systemic disorders such as hyperparathyroidism.[38]

Follow-up care

Follow-up care, essential for those with a history of renal calculi, decreases the risk of recurrent calculi, detects the presence of adverse reactions following invasive treatments, facilitates stent removal, and reinforces education on diet and lifestyle modifications. Timing for the stent removal depends on the patient's health history and the plan of care. Complications related to prolonged stent dwell-time include stent encrustation or the deposition of mineral crystals (uric acid or calcium oxalate) onto the surface and lumen of the stent.[39,40]

Stent encrustation can lead to further calculi formation causing tissue damage, obstruction, and pain.[41] Other complications include stent migration, most likely upward; infection from bacterial accumulation; and fragmentation of the stent due to deterioration.[40]

Conclusion

All indications point to an ongoing increase in the burden renal calculi place on patients and the healthcare system; therefore, prevention is essential to reduce initial and subsequent calculi formation. Nurses who understand the risk factors can teach preventive strategies to potentially reduce the risk of repeat calculi formation.

Nurses are essential to interrupting the increase of renal calculi in the US. As new treatment methods emerge, coordination of care by nurses remains an essential component in achieving successful outcomes for patients living with renal calculi. ■

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