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Nephrolithiasis

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Introduction

Nephrolithiasis, also known as kidney stones, calculi or urolithiasis, are mineral concretions with crystalline and organic elements that are found in the urinary tract. Stones form as a result of urine that has become supersaturated with a mineral, drug, or the metabolite of a drug (Khan et al, 2017).

This subject was chosen because nephrolithiasis poses a significant health and financial burden in the United States and worldwide. In the year 2000, the cost of inpatient, outpatient, and emergency services totaled an estimated \$21 billion in the United States (Ziemba & Matlaga, 2017). With the increasing incidence and prevalence of pediatric and adult nephrolithiasis, health care costs and morbidity are expected to rise (Batavia & Tasian, 2016). Obstruction of an infected kidney, bilateral obstructions, or urinary stasis with infection require immediate intervention to prevent sepsis, which can be fatal. Nephrolithiasis was once thought to be an isolated condition, but is now considered to be a systemic disease and marker for other diseases (Cunningham, Noble, Al-Modhefer, & Walsh, 2016).

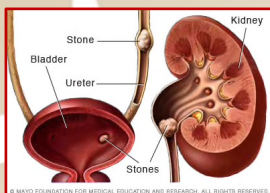


Figure 1. Kidney Stones. (Mayo Clinic, 2019).

Signs and Symptoms

Signs and symptoms of nephrolithiasis can vary in adults and children, and include:

Adults:

- Reno-ureteral colic (acute, intermittent pain) caused by contraction of smooth muscle in ureter
- Nausea and/or vomiting, due to hydronephrosis and distention of renal capsule (Cunningham et al., 2016)
- Loins pain
- Dysuria
- Urinary frequency
- Micro- or macrohematuria or brown urine
- Fever and/or chills
- Urinary tract infection (Khan et al., 2017)

Children may also have vague symptoms, such as:

- Irritability
- Unmotivated crying
- Motor agitation (Khan et al., 2017)

Presentation of Case

An adult male with a history of type 2 diabetes, hypertension, gallstones, and obesity (BMI 36) presented to the emergency department (ED) with complaints of renal colic, dysuria, hematuria, and nausea. In the ED he was evaluated by an advanced practice registered nurse (APRN) who utilized the American Urological Association's (AUA) *Medical Management of Kidney Stones: AUA Guideline* for diagnosis and management (2014), as "acute renal colic may mimic other acute abdominal conditions, making rapid and accurate diagnosis important" (AUA, 2019, para. 13).

A diagnosis of nephrolithiasis was made based on:

- History and physical, including dietary history
- Unenhanced, non-contrast helical computed tomography (CT) scan of the abdomen and pelvis
- Midstream clean catch urine sample for urinalysis, microscopy, and culture
- Serum chemistries and complete blood count (CBC)
- Exclusion of differential diagnoses, such as acute abdomen, rib fractures, lobar pneumonia, pyelonephritis, and radicular pain (AUA, 2019)

The APRN utilized the *Management of acute renal colic* pathway from the AUA (2019). It is important for healthcare providers to know which individuals require urgent or non-urgent intervention versus observation. A CT scan confirmed the presence of a stone <5mm in diameter and the individual did not have any indications for urgent intervention. A consult was placed to a urologist and the individual was scheduled for elective intervention. Pain was managed with non-steroidal anti-inflammatories and hydration was provided (AUA, 2019).

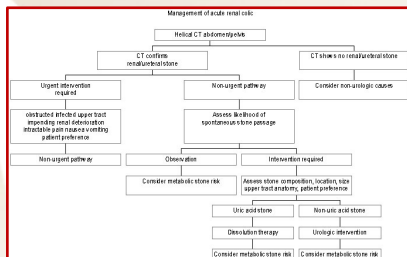


Figure 2. Algorithm for management of acute renal colic. (AUA, 2019).

Postoperatively, the stone composition was analyzed. Knowing the composition of the stone can guide treatments and strategies for preventing future stones (Khan et al., 2017). As with all newly diagnosed cases of nephrolithiasis, the individual followed up with his primary care APRN for metabolic testing, medical management, and prevention of future stone formation (AUA, 2019).

Underlying Pathophysiology

One of the kidneys' functions is the removal of waste and excessive substances from the blood. Nephrolithiasis, or kidney stones, form when:

- "Crystallization occurs when the concentration of two ions exceeds their saturation point in the solution" (Cunningham et al., 2016, p. 1114).
- Stones are generally made of soluble chemicals.
- In the urinary tract, crystallizations form when urine becomes supersaturated with a mineral, drug, or drug metabolite.
- When urine becomes supersaturated the chemical is unable to stay dissolved.
- Solutes precipitate to form crystals (AUA, 2019).
- Crystals then grow, aggregate, and adhere to urothelium and stones form (Khan et al., 2017).

Many conditions and variables influence stone formation:

- Stone composition
- Causative agent
- Underlying conditions and chronic diseases
- Idiopathic (e.g. medications like Indinavir or Atazanavir)
- Idiopathic (Khan et al., 2017)

"Increasing evidence suggests that nephrolithiasis is associated with systemic diseases like obesity, diabetes, and cardiovascular disease. Nephrolithiasis places a significant burden on the health care system, which is likely to increase with time" (Ziemba & Matlaga, 2017, p. 299).

Predisposing Factors:

- Intrinsic (e.g. sex or age)
- Extrinsic (e.g. climate, dehydration, or poorly soluble dietary contaminants)
- Anatomical structural abnormality, especially if it leads to urinary stasis (e.g. pelviureteric junction obstruction or horseshoe kidney) (Cunningham et al., 2016).
- More than 30 genetic mutations are associated with nephrolithiasis and account for approximately 15% of cases (Gee et al., 2016)

Common Stone Compositions:

- Calcium Oxalate: originate in renal papilla's epithelium, erode through the urothelium, and calcium oxalate stone(s) forms
- Uric Acid: alkaline urine is the largest risk factor; insulin resistance and chemotherapy for leukemia and lymphoma also increase risk
- Struvite or infectious: caused by urease producing organisms
- Cystine: homozygous recessive gene, excessive levels of cystine in urine (AUA, 2019)
- Relatively insoluble drugs and their metabolites (Shah & Calle, 2016)

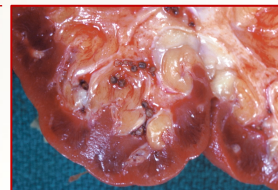


Figure 3. Renal pelvis with multiple calculi. (Anderson, 2013).

Significance of Pathophysiology

Once thought to be the result of diet and abnormal management of electrolytes by the kidneys, nephrolithiasis is now known to be a systemic disease and indicator for other systemic diseases (Ziemba & Matlaga, 2017, p. 303). Obesity, diabetes, hypertension and metabolic syndrome are considered risk factors for stone formation. Stones can then lead to hypertension, chronic kidney disease, and end-stage renal disease (Khan et al., 2017).

Conditions and diseases associated with nephrolithiasis:

- Metabolic Syndrome, increases risk with more traits
- Diabetes Mellitus, association increased with history of insulin use and severity of and higher fasting glucose and HbA1c
- Metabolic disorders
- Chronic kidney disease and end-stage renal disease
- Cardiovascular disease and myocardial infarction
- Hypertension is often diagnosed at the same time as nephrolithiasis

- Low bone mineral density and fractures (Ziemba & Matlaga, 2017)
- Aortic calcification
- Gout, uric acid stones
- Sarcoidosis
- Renal tubular acidosis (Shah & Calle, 2016)

Nephrolithiasis and obstruction can also lead to:

- Hydronephrosis
- Obstruction of an infected kidney or bilateral obstructions, which are urological emergencies that require immediate intervention
- Infection and sepsis, which can be fatal (Cunningham et al., 2016)

Obstructions can cause direct injury to the kidney:

- In the first 2 hours renal pelvic pressures are increased with decreased glomerular filtration rate
- At 6-24 hours blood flow to kidney decreases
- After 24 hours ischemia can occur (AUA, 2019)

Implications for Nursing Care

APRNs treat a wide variety of health conditions in adults, adolescents, children, and pregnant individuals in emergency, inpatient, and outpatient settings. Due to the increasing incidence of nephrolithiasis, its impact on the health and well-being of individuals, and the significant healthcare costs, APRNs need to be familiar with the diagnosis, treatment, and prevention of nephrolithiasis. For example, the care of the pediatric or pregnant patient differs from that of adult patients. The risks of ionizing radiation are much greater in younger patients (Van Batavia & Tasian, 2016), ionizing radiation poses a risk to a pregnant woman's unborn child, and obstructing stones can be dangerous to the mother and fetus (Rodriguez & Sacco, 2015).

As primary care providers, APRNs play a crucial role in disease prevention, health maintenance, and education. There are numerous strategies available for the prevention of nephrolithiasis, many of which are dietary and specific to the type of stone that was formed (Shah & Calle, 2016).

Additional risk factors for stone formation:

- Low urine volume
- Hypercalciuria, hyperoxaluria, hypercitraturia, hyperuricosuria, cystinuria
- Male gender
- Metabolic Syndrome (insulin resistance, obesity, hypertension, dyslipidemia, systemic inflammation)
- Cholelithiasis
- Sucrose, fructose, sugar-sweetened soda
- Supplemental calcium (Shah & Calle, 2016)

New and recurrent stone formers should undergo metabolic testing:

- 24-hour urine collection
- Analysis of stone composition
- Serum chemistries, alkaline phosphate, albumin
- Serum intact parathyroid hormone level (for individuals with hypercalcemia) (AUA, 2019)

Prevention and Maintenance Strategies:

- Fluid intake to produce 2.5 liters of urine per day
- Manage underlying conditions
- Pharmacologic therapy specific to stone composition
 - Thiazide diuretics
 - Potassium citrate
 - Allopurinol
 - Pyridoxine
 - Cystine-binding thiol
 - Urease inhibitors
- Diet modifications specific to stone composition
 - Limit sodium intake
 - Increase dietary calcium intake
 - Restrict nondairy animal protein
 - Increase intake of fresh fruit and vegetable
 - DASH diet (Shah & Calle, 2016)

Conclusions

Nephrolithiasis, which was once considered to be an isolated condition, is now known to be a systemic disease and significant cause of morbidity, mortality, and healthcare spending. With increasing prevalence, incidence, and stone recurrence rates worldwide, it is imperative that health care providers receive proper education on the pathophysiology, diagnosis, management, and prevention of nephrolithiasis (Ziemba & Matlaga, 2017).

Key Points:

- Stones form as a result of supersaturated urine
- Many factors contribute to nephrolithiasis
- Stone recurrence is preventable with proper diagnosis and treatment, which includes lifestyle and diet modifications specific to the type of stone
- Nephrolithiasis is associated with and is known to cause other serious systemic diseases

References



Additional Sources

Healthcare providers:

American Urological Association. (2014). Medical management of kidney stones. Retrieved from <https://www.auanet.org/guidelines/kidney-stones-medical-management-guideline>

American Urological Association. (2016). Surgical management of stones: AUA/Endourology Society guideline. Retrieved from <https://www.auanet.org/guidelines/kidney-stones-surgical-management-guideline>

Patients:

National Institute of Diabetes and Digestive and Kidney Diseases. (2017, May). Kidney stones. Retrieved from <https://www.niddk.nih.gov/health-information/urologic-diseases/kidney-stones>



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Perform repeat stone analysis in individuals not responding to treatment (AUA, 2014).