CHAPTER 97
UROLITHIASIS

Philip M. Mshelbwala
Hyacinth N. Mbibu

Introduction

Urinary stones are relatively uncommon in the paediatric age group; however, the prevalence seems to be on the increase and the tendency towards urinary lithiasis in males and females is the same in childhood.[1,2] The clinical features are often vague and nonspecific, so a high index of suspicion is usually required for diagnosis. Limited investigations tend to be performed in children presenting with urinary calculi,[3] and this may affect the prevalence of urinary stones in children. The prevalence is also affected by race, genetics, diet, and geographic location.[4]

Dermographics

The decreased prevalence in children may be due to the low rate of secretion of endogenous oxalate. Low levels of testosterone at childhood may protect children from forming the most common stones.[5] Stones have been found to be more common in Western countries and parts of Asia than in East and West Africa. The overall incidence in Africa is estimated at 2–3% of the general population, with lower figures reported in Nigeria.[6,7] The incidence may also vary within the same country.[8]

Aetiology/Pathogenesis

Urinary stones may be due to metabolic causes, congenital anomalies, or infections and can be found in any part of the urinary system, from the kidney to the urethra. They may also migrate from the upper urinary tract to lower sites.

In about 75% of cases of urinary stones in children, an identifiable predisposing cause can be found. It is not uncommon to find more than one factor in the same patient.[9] The causes are metabolic (40%), urinary tract abnormality (25%), urinary tract infection, or UTI (10%), with the remaining being idiopathic.[10] The hot climate in some parts of Africa has also been implicated.[11,12]

Metabolic Causes

The most common metabolic cause in children is hypercalciuria, occurring in 30–50% of cases in some series.[13] Certain diets and disorders of renal tubular transport may predispose to hypercalciuria, although high urinary calcium may be detected in 3–4% of normal children.[14] Cystinuria, hyperoxaluria, hyperuricosuria, hypocitric aciduria, and hyperxanthinuria are other metabolic causes.[15] change in diet and other social habits may have led to an increase of urinary stones in children. Improved health care has also led to the emergence of urinary stones in patients who previously would not have survived, such as premature infants with hypercalcinosis and children with cystic fibrosis presenting with urinary stones.[10]

Congenital Abnormalities

Genitourinary congenital abnormalities that cause obstruction to the free flow of urine also predispose to stone formation. These include posterior urethral valves, bladder exstrophy, vesicoureteric reflux, meatal stenosis, medullary sponge kidney, and pelviureteric junction obstruction. Neuropathic bladders from spinal bifida may lead to stone formation.

Urinary Tract Infection

UTI is an important predisposing factor in infants and younger children. The organisms commonly isolated are urease splitting species of *Proteus*, *Klebsellia*, *Pseudomonas*, *Staphylococcus*, and some anaerobes. These microbes split urea, leading to an increase in the urinary pH, which in turn raises the urinary concentration of magnesium ammonium phosphate ions, creating a favourable environment for stone formation. The presence of oxalate-splitting bacteria in urine has also been implicated.

Diet

Various foods and fluids that may result in the excessive excretion of substances that produce stones have a significant effect on the incidence of urinary stones. These include purines, oxalates, calcium, phosphates, and uric acid. Diets with excessive vegetables, high levels of animal protein (such as beef, chicken, and lamb), milk, and ice cream are associated with childhood lithiasis.[2]

Idiopathic

The cause of stone formation may be unidentifiable in a number of patients, especially in the adolescent age group; this situation is similar in adults. Due to the possibility of more than one predisposing factor, thorough clinical and exhaustive investigative parameters are desired in the proper assessment of these children.[8]

Pathophysiology

The pathophysiology of urinary stone formation is quite complex and involves the interaction of various factors,[16] including (Figure 97.1):

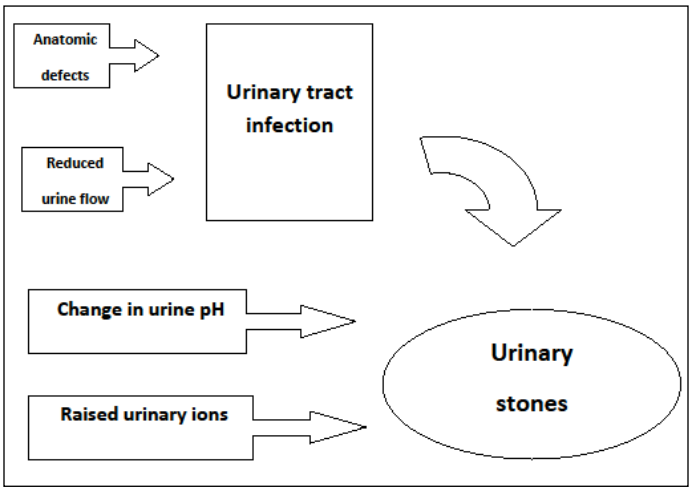

Figure 97.1: Pathophysiology of urinary stones.

- urinary concentration of stone-forming ions, such as calcium, phosphate, oxalates, and uric acid;
- urinary pH;

- rate of flow of urine;
- balance between promoter and inhibitory factors of crystallisation (e.g., citrate, magnesium, pyrophosphate, nephrocalcin, Tamm-Horsfall glycoproteins, and glycosaminglycans); and anatomic factors that predispose to urinary stais (e.g. congenital anomalies), foreign bodies, and some drugs such as acetazolamide.

All these factors should be treated if management is to be successful and recurrence minimised.

The chemical composition of urinary stones in children is similar to those found in adults. About 50% are calcium oxalate, 15–25% are calcium phosphate, and 10–15% are mixed (calcium oxalate and calcium phosphate). The others are struvite [magnesium ammonium, phosphate] (15–30%), cystine (6–10%), and uric acid (2–10%).[9,13]

Due to their relative high densities (based on their calcium content), most of these stones are visible on plain radiographs, some better than others.

Clinical Presentation

History

The average age at presentation is 8–10 years with a male-to-female ratio of 1.5:1.

The evaluation of a child with suspected urolithiasis requires a high index of suspicion because the symptoms may be vague and varied. These symptoms include:

1. *Pain/colic:* Pain is the most common symptom of urolithiasis in children. Frank renal colic is a feature in adolescents that waxes and wanes in severity; the pain may range from a mild ache to severe discomfort. The pain can last 20–60 minutes. Acute generalised abdominal pain is more common in younger children,[17] and diagnosis is made on work-up for UTI.

2. *Recurrent UTI:* A history of recurrent UTI, especially in younger children, should be a pointer and deserves further investigation.

3. *Crying on micturition:* Crying or pain on micturition (in older children) is also a common presenting feature; this may start early in life. The child may also tug at the penis during micturition.

4. *Urinary retention:* Urinary retention may be the initial symptom of urinary stones.

5. *Gross haematuria:* This alarming symptom, which is present in 30–50% of cases and may occur in combination with colic is the main presenting feature of urinary stones in older children. Haematuria may also be microscopic.

6. *Nausea and vomiting:* Unexplained nausea and vomiting may be due to stones. A deeper probing into the patient's history may reveal more symptoms.

7. *Fever:* Fever may occur in children with urinary stones, especially if associated with UTI.

Other symptoms include frequency of urination, tugging or pulling at the phallus, spontaneous passage of stones, failure to thrive, and rectal prolapse.[7]

A number of children with urinary stones, however, are asymptomatic, particularly those with staghorn stones; they are discovered only during investigation for other conditions, such as recurrent UTIs.

Review of medical and family history is pertinent because urinary stones may be recurrent or familial. The dietary history, especially high-protein foods, salts, and food and vitamin supplements, must be sought.

The daily fluid intake should be estimated because low fluid intake, especially in hot climates, has been shown to be a predisposing factor to urinary stones. A history of drugs that affect uric acid and calcium metabolism is also important.

Physical Examination

Findings on physical examination of a child with urinary stones vary widely.

- *Acute episode:* The patient most likely to present with acute colic is the older child in his teens; there is painful distress, listlessness, and there may be fever (if the cause is infective). Nonspecific generalised abdominal pain is encountered in younger children, and tenderness may be noted on examination.
- *Chronic stones:* The child may show signs of failure to thrive resulting from recurrent UTI and renal failure.
- *Normal child:* The child may appear grossly normal with no physical signs.

Investigations

Urine Tests

Both urinalysis and urine culture are indicated. Urine should be analysed for pH. A high pH points towards the presence of urea-splitting bacteria, whereas uric acid or cystine stones form in the presence of low pH. Levels of calcium, oxalate, citrate, uric acid, and cystine are also estimated. A 24-hour urine sample in older cooperative patients gives more information. Urine microscopy may reveal casts, crystals, haematuria, and pyuria. Urine culture would also be useful in isolating the offending organism when present, and the sensitivity pattern would guide antibiotic use. Clean midstream urine can be collected in older patients, but clean catheterisation or a suprapubic tap may be necessary to avoid contamination in some younger patients.[17,18]

Imaging

Imaging is useful in confirming the presence of a stone and also in detecting abnormalities of the urinary tract that may have predisposed to stone formation.

- *Plain radiographs* (Figure 97.2) can diagnose about 90% of urinary stones. In temperate countries, 60–70% of stones are renal at the time of diagnosis. When they are seen in the ureter, bladder, or urethra, the stones often have migrated from the kidney. In contrast, in hotter climates, more bladder stones are seen and have been referred to as endemic bladder stones.

Figure 97.2: Plain radiograph showing stone.

- *Ultrasonography* (US) is useful in detecting kidney stones but less reliable for ureteric calculi. US can also evaluate the structural state of the urinary system, picking up congenital malformations that may predispose to stone formation. Obstructive features, such as hydroureters and hydronephrosis, are also diagnosed.
- *Intravenous urography* (IVU) would demonstrate less opaque or radiolucent stones (not picked up by plain radiography) as filling defects in the urinary system. Renal functional status can also be assessed.

- *Helical computed tomography* (CT) scans have recently been shown to be useful in diagnosing urinary stones.[19] These give a three-dimensional image, are able to detect almost all types of stones, and can determine whether the stone is causing any obstruction.
- *Retrograde pyelgraphy* may rarely be needed if a radio-opaque stone is difficult to locate by other means.

Stone Analysis

Where the stone has been passed out spontaneously or obtained surgically, it should be analysed for its chemical composition. Apart from visualising the stone, other structural abnormalities that may predispose to calculi formation may be detected. Stones can also be extracted during the procedure.

Endoscopy

Urethrocystoscopy is used with increasing frequency in children; this assesses the urethra, bladder, and ureteric orifices.

Blood Analysis

The serum levels of calcium, phosphate, creatinine, uric acid, sodium, potassium, alkaline phosphate, albumin, and bicarbonate should be estimated. Elevated levels may suggest the cause of the stones in metabolic cases and provide useful information regarding treatment.

Treatment

The definitive treatment of urinary stones in children should be directed at the specific cause; however, general and medical measures are important in all patients.[1]

Medical

A high fluid intake is encouraged to ensure good urinary output, especially in patients living in hotter climates. This increased intake is continued after definitive treatment to reduce the chance of recurrence.

The older child is more likely to present with typical acute ureteric colicky abdominal pain. The pain in the younger child is more usually a generalised abdominal ache. Acute pain may be managed with narcotic analgesics and antispasmodics. The agitated child necessarily needs to be calmed; otherwise, further evaluation may be difficult.

Appropriate antibiotic therapy where UTI has been established is mandatory. Bacteria commonly may be trapped in the core of calculi and therefore be inaccessible to antibiotics. Treatment may continue over prolonged periods to achieve permanent cure and to reduce the risk of renal scarring and recurrent UTIs.

Patients with hypercalciuria are advised to reduce dietary sources of calcium such as milk and cheese; low sodium and potassium-enhanced diets are also beneficial. Those with hyperoxalouria are to avoid nuts, spinach, tea, and cocoa-based drinks and foods. In patients with citric acid deficiency, dietary supplementation of sodium and potassium citrate increases urinary citrate level, thus decreasing the chance of stone formation.[20]

Potassium citrate is commonly used as an effective calcium stone inhibitor. It is readily absorbed from the gastrointestinal tract, and after excretion in the urine, inhibits the crystallisation of stone-forming calcium salts by binding the calcium ion, thus decreasing its urinary saturation and inhibiting the nucleation and crystal growth of calcium oxalate.

Extracorporeal Shock-Wave Lithotripsy

Extracorporeal shock-wave lithotripsy (ESWL), a noninvasive mode of treatment, was initially reserved for adult patients but is used with increasing frequency and success in children.[9,21,22] The stone is localised by US scan or x-ray, and ultrasonic shock waves are beamed at the site to disintegrate the stone, which is subsequently passed out or extracted.

Indications for the use of ESWL are growing; they commonly include a large single stone and no evidence of urinary tract obstruction that may impede expulsion of fragments. Obesity and other concomitant medical illnesses may be relative contraindications.

Surgery

A wide range of surgical options are available for the treatment of urinary stones in children; these may be open or minimally invasive. Indications for surgery include failed medical treatment and failed or contraindicated ESWL. Surgery can also be used in conjunction with other forms of therapy. Surgery directed at correcting structural abnormalities is also indicated because this can serve to reduce the risk of recurrence.

Minimally invasive surgery

Endoscopic procedures such as ureteroscopic, cystoscopic, and nephroroscopic lithotomy are commonly used to treat stones in children, especially in the developed countries. These techniques may be used alone or together with ESWL. Percutaneous nephrolithotomy is also a popular treatment option. More recently, laser has also been used to treat urinary stones.[19]

Open Surgery

In developing countries due to the limited availability of endoscopic equipment, treatment of urinary stones is most commonly by open procedures. Pyelolithotomy, nephrolithotomy, ureterolithotomy, or cystolithotomy are used to extract the stones, depending on the site.[7]

The most common nonanatomic cause of paediatric lithiasis is hypercalciuria. This must be diligently searched for and treated. If not, it remains an important cause of recurrent lithiasis in children. Treatment must also be directed towards the management of the underlying cause of the stone where this is identified.[1] Anatomic anomalies such as posterior urethra valves, vesicoureteric reflux, and pelviureteric junction obstruction should be corrected.

Prevention

Long-term follow-up of children with urinary stones is necessary to detect recurrence. Adequate fluid intake and dietary adjustment, along with infection control if used in concert, help to reduce the rate of recurrence.

Regular imaging, such as ultrasonography, urinalysis, and other means of monitoring may be indicated in these patients.

Key Summary Points

1. Urinary stones are relatively uncommon in children.
2. Changes in diet and other social habits may have led to an increase of urinary stones.
3. In a majority of patients, an identifiable predisposing cause can be found, and more than one factor may be responsible in the same patient.
4. Presentation may be acute or nonspecific and varied; thus, diagnosis is often difficult or delayed.
5. A wide range of imaging techniques as well as urine and serum biochemical analysis are needed for evaluation.
6. Helical noncontrast CT is useful in confirming the presence of a stone and also in detecting abnormalities of the urinary tract.
7. Treatment should be directed towards removing the underlying cause(s) of the stone, where this is identified, as well as dealing with the pathological effects of the stone.
8. Long-term follow-up of children with urinary stones is necessary to detect recurrence.

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