

Review Article

Urinary stones in children

¹PM Mshelbwala¹EA Ameh and ²HN Mbibu

¹Division of Paediatric Surgery and ²Division of Urology

Department of Surgery, Ahmadu Bello University, Zaria, Nigeria

Request for Reprints to Dr Mshelbwala P M. Division of Paediatric Surgery, Department of Surgery, Ahmadu Bello University-Zaria, Nigeria.

E-mail: philmari@yahoo.com

Abstract

Urinary stones were previously thought to be uncommon in the paediatric age however this may be due to differences in presentation and evaluation of children with stones. There are variations in the incidence worldwide; affected by diet and climate.

Common aetiological factors are metabolic changes, urinary tract abnormality and urinary tract infections. The patho-physiological processes leading to stone formation are multifactorial involving interplay of increasing concentration of particles in urine, such as calcium, magnesium, phosphates, oxalates, alteration in urine pH and a decrease in the flow of urine or stasis.

Presentation may be acute or non-specific and varied thus diagnosis is often difficult or delayed and a wide range of imaging techniques, urine and serum biochemical analysis are needed for evaluation.

Treatment must also be directed towards removing the underlying cause(s) of the stone where this is identified as well as dealing with the pathological affects of the stone if recurrence is to be minimized.

Introduction

The usual peak of urinary stones is the twenties to the forties with a male preponderance. Most patients however present with symptoms beginning from their teens¹⁸. Urinary stones are relatively uncommon in the paediatric group and the tendency towards urinary lithiasis in males and females is the same in childhood¹⁹. Limited investigations tend to be performed in children presenting with urinary calculi¹ and this may affect the prevalence of urinary stones in children. The prevalence is also affected by race, genetics diet and geographical location². The low rate of secretion of endogenous oxalate in children due to low levels of testosterone at childhood may protect children from forming the commonest stones²⁰. Stones have been found to be more common in western countries and parts of Asia, than in East and West Africa. The overall incidence is however estimated at 2-3% of the general population, with lower figures reported in Nigeria^{3, 4}. Change in diet and other social habits may have led to an increase of urinary stones in children. Improved

healthcare has also led to the emergence of urinary stones in patients who previously wouldn't have survived, such as premature infants with hypercalcinosis and cystic fibrosis presenting with urinary stones.⁵

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 and may migrate from the upper urinary tract to lower sites.

Aetio-pathogenesis

In about 75% of cases of urinary stones in children an identifiable predisposing cause can be found and it is not uncommon to find more than one factor in the same patient⁶. The causes in one series (figure 1) were metabolic 40%, urinary tract abnormality 25%, urinary tract infection (UTI) 10%, with the remaining being idiopathic⁵. Hot climate has also been implicated^{7,8}

Fig1: Etiology of stones.

Metabolic causes

The commonest metabolic cause in children is hypercalciuria occurring in 30-50% cases in some series⁹. Certain diets and disorders of tubular renal tubular transport may predispose to hypercalciuria, though high urinary calcium may be detected in 3-4%

of normal children¹⁰. Cystinuria, hyperoxaluria, hyperuricosuria, hypocitric aciduria and hyperxanthinuria are other metabolic causes¹¹.

Congenital abnormalities

Genitourinary Congenital abnormalities which cause obstruction to the free flow of urine also predisposes to stone formation. These include posterior urethral valves, bladder extrophy, 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)

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.

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. Excessive vegetables, milk and ice cream are associated with childhood lithiasis¹⁹.

Idiopathic

The cause of stone formation may be unidentifiable in a number of patients especially in the adolescent age group; this is similar to what obtains 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.

- Urinary pH
- Rate of flow of urine
- The balance between promoter and inhibitory factors of crystallisation, for example, citrate, magnesium, pyrophosphate and nephrocalcin, glycoproteins (Tamm Horse Fall) and glycosaminoglycans

Pict 1 Idiopathic Bladder stone in an 8 year old



Post op smooth stone specimen from (PicT)



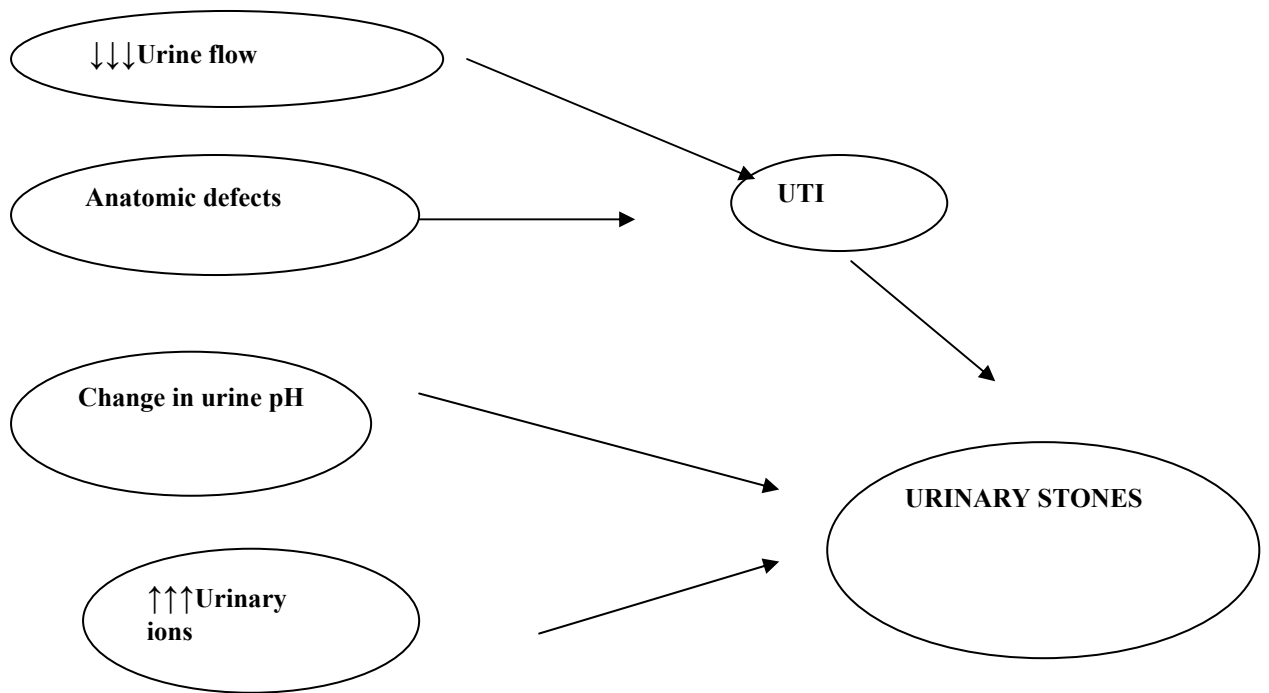
Pathophysiology

The pathophysiology of urinary stone is quite complex and involves the interaction of various factors, including:¹ see (fig1)

- Urinary concentration of stone forming ions such as calcium, phosphate, oxalates, uric acid
- Anatomic factors that predispose to urinary stasis, for example, congenital anomalies, foreign bodies and some drugs like acetazolamide

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

Fig 2 Pathophysiology of urinary stones

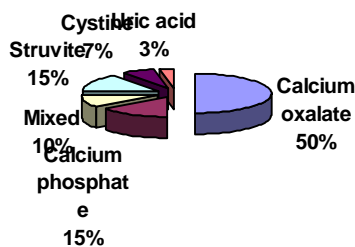


Chemistry Of Urinary Stones

The chemical composition of urinary stones in children is similar to those found in adults. About one-half are calcium oxalate, calcium phosphate account for 15-25%, while 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%^{6,9} (Fig 3). Due to their relative high densities (based on their calcium content), most of these stones are visible on plain radiographs but some better than others.

Fig 3 composition of stones



Evaluation

Clinical Features

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 since the symptoms may be vague and varied.

1. **Recurrent UTI:** A history of recurrent urinary tract infection especially in younger children should be a pointer and deserves further investigation
2. **Crying on micturation:** Crying or pain on micturation (in older children) is also a common presenting feature and this may start early in life. The child may also tug at the penis during micturation.
3. **Urinary retention:** This may be the initial symptom of urinary stones.
4. **Pain/Colic:** Frank renal colic is a feature in adolescents but acute generalized abdominal pain is commoner in younger children¹² and diagnosis is done on work-up for UTI.

5. **Gross haematuria:** This alarming symptom in combination with colics is the main presenting feature of urinary stones in older children.
6. **Nausea and vomiting:** Unexplained nausea and vomiting may be due to stones and a deeper probing into the history may reveal more symptoms
7. **Fever:** Fever may occur in children with urinary stones especially if associated with UTI.

Other symptoms include frequency, tugging or pulling at the phallus, spontaneous passage of stones, failure to thrive and rectal prolapse⁴.

Asymptomatic: A number of children with urinary stones are asymptomatic, particularly those with stag horn stones, and this is only picked up during investigation for other conditions such as recurrent UTI.

Review of medical and family history is pertinent as 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 as 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.

1. **Acute episode:** The patient likely to present with an acute colic is the older child in his teens; there is painful distress, listlessness and there may be fever (if the cause is infective). Non-specific generalized
 - i. Plain radiographs 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 but in hotter climates more bladder stones are seen and have been referred to as endemic bladder stones^{6,24}.
 - ii. Ultrasonography is useful in detecting kidney stones but less reliable for ureteric calculi. Ultrasonography can also evaluate the structural state of the urinary system, picking up congenital malformations that may predispose to stone formation. Obstructive features such as hydronephrosis and hydronephrosis are also diagnosed.
 - iii. Intravenous urography would demonstrate less opaque or radiolucent stones (not picked by plain radiography) as filling defects in the

abdominal pain is encountered in most younger children and tenderness may be noted and on examination.

2. **Chronic stones:** The child may show signs of failure to thrive resulting from recurrent UTI renal failure.
3. **Normal child:** The child may appear grossly normal with no physical signs.

Investigations

1. **Urine analysis:** Urine should be analysed for pH, a high pH pointing towards the presence of urea-splitting bacteria, while 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 would give more information. Urine microscopy may reveal casts, crystals, haematuria and pyuria. Culture would also be useful in isolating the offending organism when present and the sensitivity pattern would guide antibiotic use. Clean mid stream urine can be collected in older patients while clean catheterization or suprapubic tap may be necessary to avoid contamination in some younger patients^{12,13}.
2. **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.
3. **Imaging:**
 - iv. Helical CT scans have recently been shown to be useful in diagnosing urinary stones¹⁴
 - v. Retrograde pyelography may be rarely needed if a radio-opaque stone is difficult to locate by other means.
4. **Stone analysis:** Where the stone has been passed out spontaneously or obtained surgically, it should be analysed for its chemical composition.
5. **Endoscopy:** Urethrocystoscopy is used with increasing frequency in children; this assesses the urethra, bladder and ureteric orifices.
6. Apart from visualizing the stone, other structural abnormalities that may predispose to calculi formation may be detected. Stones can also be extracted during the procedure.

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.

Medical

1. **High fluid in take:** This is encouraged to ensure a good urinary output especially in patients living in hotter climates. This increased intake is continued after definitive treatment to reduce the chance of recurrence.
2. **Pain control:** The older is more likely to present with a 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 calm otherwise further evaluation may be difficult.
3. **Control of infection:** Appropriate antibiotic therapy where UTI has been established is mandatory. Bacteria commonly may be trapped in the core of calculi and inaccessible to antibiotics and treatment may continue over prolonged periods to achieve permanent cure and to reduce the risk of renal scarring and recurrent UTI.
4. **Dietary adjustment:** 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. While those with hyperoxaluria 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 stone formation¹⁵.

5. **Drugs:** 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 crystallization 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 (Eswl)

This non-invasive mode of treatment was initially reserved for adult patients but is used with increasing frequency and success in children^{5, 16, 17}. The stone is localized by ultrasound scan or x-ray and ultrasonic shock waves are beamed at the site to disintegrate the stone, which is subsequently passed out or extracted Fig 2.

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

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 includes failed medical treatment, failed or contraindicated ESWL. Surgery can also be used in conjunction with other forms of therapy. Surgery directed to correcting structural abnormalities is also indicated as this can serve to reduce the risk of recurrence.

Surgery

Minimally invasive surgery: Endoscopic procedures such as ureteroscopic, cystoscopic and nephroscopic 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; recently laser has also been used to treat urinary stones⁵.

Open surgery: In developing countries however, due to 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 site⁴.

Pict 2. 13 year old girl with bilateral renal stones At an ESWL session.



Treatment Of Underlying Cause

The commonest non- anatomic cause of pediatric 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 causes of the stone where this is identified. Anatomic anomalies like 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 helps to reduce the rate of recurrence.

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

Conclusion

Urinary stones occur frequently in children, but due to the non-specific nature of symptoms, detection may be delayed.

An elaborate history with emphasis on dietary and family history, urine analysis along with imaging techniques, remain the corner stone of diagnosis. For therapy to be effective, both medical and surgical modalities may need to be employed. A long-term follow up is necessary to prevent or detect recurrence.

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