How is Stones in Paediatrics Different from Adults?

Lee Say Bob
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Epidemiology

- In adults, male affected more
- In paeds, boys and girls are equally affected.
- Most paediatric stones are located in the UUT.
- Bladder stones
  - are still common in under-developed areas of the world &
  - are usually ammonium acid urate & uric acid stones, strongly implicating dietary factors.
Epidemiology

- Adults have higher risk for developing stones than do children.

- Incidence in adults 101.8 per 100,000 (1)
  - Male 306 per 100,000 person-years; Female 95 person-years (2,3)

- Incidence in children 17.7 per 100,000 males, 12.4 per 100,000 females aged 10-19 y/o (4).

Epidemiology

- In accordance with adults, stones are more prevalent in children of Caucasian decent as compared with African American individuals.
- The risk in Hispanic children is higher than in African American children, but not as high as in Caucasian children.
Changing epidemiology

• **Incidence** of renal stones across entire pediatric age spectrum is ↑ in trend (1).

• **Girls** are more susceptible to nephrolithiasis than boys.

• Absence of male predilection to kidney stones during childhood.

Incidence of pediatric nephrolithiasis in South Carolina.

In 2007, the incidence of nephrolithiasis for girls was 21.9 versus 15.3 for boys, which reflects a change from the similar incidence (7.7 versus 8.0) observed in 1996. Incidence is expressed as number of unique cases of nephrolithiasis per 100,000 children from each specific demographic (6).

Why increasing incidence in pediatrics stone disease?

- Obesity – increased lithogenic solute concentration and decreased urinary pH
- Changes in dietary habit
  - Increased sodium intake
  - Decreased calcium intake
  - Decreased water intake
  - Increased use of antibiotics
Epidemiology

• Paediatric stone disease
  – recurrent nature>>
    • every effort should be made to discover the underlying metabolic abnormality
    • obtaining a stone-free state with interventional mx and close follow-up are of the utmost importance
  – own unique features, which are different in both presentation & tx compared to adults
Classification systems

• Urinary stone formation is the result of a complex process involving
  – metabolic,
  – anatomical factors &
  – presence of infection
Metabolic factors

• Dent disease
  – is a rare X-linked recessive inherited condition that affects the proximal renal tubules of the kidney.
  – It is one cause of Fanconi syndrome, and is characterized by tubular proteinuria, excess calcium in urine, formation of calcium kidney stones, nephrocalcinosis, and chronic kidney failure.

• Primary hyperoxaluria

• Lesch-Nyhan syndrome
  – def of the enzyme hypoxanthine-guanine phosphoribosyltransferase (HGPRT)
Metabolic factors

• Pediatric stone formers predominantly form calcium-based calculi (72-88%).[1,2]

• Uric acid stones (1,2)
  – 2-3% of stone in pediatric patient
  – 11% of stone in adult

Metabolic factors

• >50% of affected children have an identifiable metabolic risk factor.
  – Hypercalciuria 50-97% of all metabolic cases
  – Hypocitraturia 26%
  – Hyperuricosuria 8%
  – Hyperoxaluria 5%
Why do younger patients form more calcium based stones and fewer uric acid stones?

- Pediatric pts generally have a slightly higher urinary pH than adults (6.44 vs 6.05) [1]
- Uric acid stones form preferentially in acidic urine.

Promoters of stone formation

• Children have **higher urinary calcium excretion** than adults when adjusted for creat excretion or body weight [1,2].

• **Urinary oxalate excretion** (adjusted for creatinine excretion) is considerably **higher** in children than in adults [3].

• Hyperoxaluria is present in approximately 14% to 18% of adult stone formers (4) and approximately 11% to 20% of pediatric SFs (5).


Inhibitors of stone formation

• **Urinary citrate levels are highest in young children and decrease into adulthood (1,2),** but relative hypocitraturia is a common finding in pediatric nephrolithiasis.

• **Many reports emphasise the significance of hypocitraturia in pediatric calcium stone ds.**
  – 30% to 60% in children with calcium stone ds.

Normal metabolic profile of urine in children

<table>
<thead>
<tr>
<th>Normal 24-h Urine Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium</td>
</tr>
<tr>
<td>Oxalate</td>
</tr>
<tr>
<td>Uric acid</td>
</tr>
<tr>
<td>Citrate</td>
</tr>
<tr>
<td>Cystine</td>
</tr>
<tr>
<td>Total volume</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Normal Spot Urine Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium/creatinine</td>
</tr>
<tr>
<td>Infant</td>
</tr>
<tr>
<td>Child</td>
</tr>
<tr>
<td>Oxalate/creatinine</td>
</tr>
<tr>
<td>Child &gt; 4 yo</td>
</tr>
<tr>
<td>Child &lt; 4 yo</td>
</tr>
<tr>
<td>Infant &lt; 6 mo</td>
</tr>
<tr>
<td>Citrate/creatinine</td>
</tr>
</tbody>
</table>
Anatomical factors

• Result in urinary stasis
  – PUJO
  – Horseshoe kidney
  – Polycystic kidney
Presentation

• Presentation tends to be **age-dependent**
  – Very young children -- *non-specific symptoms* (e.g. irritability, vomiting)
  – Older children
    • symp such as *flank pain and haematuria* more common
    • Haematuria (gross), occurring with or w/o pain, is less common
Presentation

- The **classic renal colic of the adult is uncommon**.
- **Microscopic haematuria** may be the sole indicator and is more common in children.
- In some cases, UTI may be the only finding leading to radiological imaging.
Imaging

• US should be used as a first study
• Simple KUB X-ray
• The most sensitive test-- non-contrast helical CT scan
  – safe & rapid, 97% sensitivity & 96% specificity
• IVP is rarely used in children
  – may be needed to delineate the caliceal anatomy prior to percutaneous or open surgery
Metabolic evaluation

• D/t high incidence of predisposing factors for urolithiasis in children & high stone recurrence rates, every child with urinary stone should be given a complete metabolic evaluation \(^{(1,2)}\).

Metabolic evaluation

• Metabolic evaluation includes:
  – Family & pt hx of metabolic problems
  – Analysis of stone composition (following stone analysis, metabolic evaluation can be modified according to the specific stone type)
• Metabolic evaluation
  – BUSE, creatinine, calcium, phosphorus, ALP, uric acid, total protein, carbonate, albumin, and PTH (if there is hypercalcaemia)
  – Spot urinalysis & culture, including ratio of calcium to creatinine
  – Urine tests, including a 24h urine collection for calcium, phosphorus, magnesium, oxalate, uric acid citrate, cystine, protein, and creatinine clearance.
Algorithm for metabolic investigations in urinary stone disease in children

Paediatric stone patient

Elimination of stones by spontaneous passage or active removal (SWL, surgery)

Stone analysis

My Ammonium phosphate (struvite)
- urine culture
- possibly urease producing bacteria

Uric acid stone
- urine pH
- urine and serum uric acid levels

Cystine
- urine pH
- urine cystine level

Calcium stones: CaOx-CaPO
- cyslitruria
- High fluid intake
  - potassium citrate
  - 3-4 mEq/kg/d
  - mercaptopropionylglycine
  - 10-15 mg/kg/d

Total elimination of stone (surgery/SWL) antibiotics

Alkalai replacement - K citrate
- Allopurinol (10 mg/kg)
- low purine diet

Hyperparathyroidism
- hypercalciuria
- hyperuricuria
- K citrate
- diet low in ox.
- K citrate
- pyridoxine

Further investigation for RTA
- urine pH < 5.5
- hypocitraturia

SWL = extracorporeal shockwave lithotripsy; HCTZ = hydrochlorothiazide; PTH = parathyroid hormone; RTA = renal tubular acidosis.
Paediatric stone patient

Elimination of stones by spontaneous passage or active removal (SWL, surgery)

Stone analysis

**Mg Ammonium phosphate (struvite)**
- urine culture
  - possibly urease producing bacteria
  - Total elimination of stone (surgery/SWL) antibiotics

**Uric acid stone**
- urine pH
- urine and serum uric acid levels
- acidic urine hyperuricosuria hyperuricemia

**Cystine**
- urine pH
- urine cystine level
cystinuria
- High fluid intake potassium citrate
  - 3-4 mEq/Kg/d
  - mercaptopropionylglycine
    - 10-15 mg/kg/d

Alkali replacement - K citrate
Allopurinol (10 mg/kg)
low purine diet
Calcium stones
CaOX-CaPO

serum PTH hypercalcaemia

urine - blood pH
urine - blood Ca - uric acid levels, Mg, Phosphate
urine Ca-Oxalate-Citrate-Mg-Uric A -Phosphate

urine pH > 5.5

Hyperparathyroidism

hypercalciuria

K-citrate diet (normal calcium low sodium intake)
HCTZ (diuretic)

hyperoxaluria

Diet low in ox.
K-citrate pyridoxine

hyperuricosuria

Alkali replacement (K-citrate) allopurinol

hypocitraturia

Citrate replacement K-citrate

Further investigation for RTA

urine pH < 5.5

SWL = extracorporeal shockwave lithotripsy; HCTZ = hydrochlorothiazide; PTH = parathyroid hormone; RTA = renal tubular acidosis.
Management

• Most paediatric stones can easily be managed by ESWL
  – ESWL – GA (<10y), intravenous sedation (>10 y)
• Endoscopic tx can be applied easily for ureteric & bladder stones
• PCNL is possible for kidney stones
• Small portion of children -- open surgical approach
Management

- In children (particularly smaller children), PCNL has some advantages, such as
  - smaller skin incision,
  - single-step dilation and sheath placement,
  - good working access for paediatric instruments,
  - variable length, &
  - lower cost (1,2)

Management

• Good candidates for open stone surgery include
  – very young children with large stones and/or a congenitally obstructed system, which also requires surgical correction.
  – children with severe orthopaedic deformities that limit positioning for endoscopic procedures
Management

- Availability of smaller size endourological equipment
  - manage paediatric ureteral stones using endoscopic techniques (URS).
  - laser energy is easier to use in smaller instruments and is more useful for paediatric cases.

Management

• A recent literature review contains a growing number of case series on the use of flexible ureterorenoscopic interventions in children.
  – Intrarenal & ureteric stones
  – Important problem was the inability to obtain retrograde access to the ureter in approximately half of the cases (1).
# Recommendations for interventional management in paediatric stones

<table>
<thead>
<tr>
<th>Stone size and localisation*</th>
<th>Primary treatment option</th>
<th>LE</th>
<th>GR</th>
<th>Secondary treatment options</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staghorn stones</td>
<td>PCNL</td>
<td>2</td>
<td>B</td>
<td>Open/SWL</td>
<td>Open/SWL Multiple sessions and accesses with PCNL may be needed. Combination with SWL may be useful.</td>
</tr>
<tr>
<td>Pelvis &lt; 10 mm</td>
<td>SWL</td>
<td>1</td>
<td>A</td>
<td>RIRS/PCNL/MicroPerc</td>
<td></td>
</tr>
<tr>
<td>Pelvis 10-20 mm</td>
<td>SWL</td>
<td>2</td>
<td>B</td>
<td>PCNL/RIRS/MicroPerc/Open</td>
<td>Multiple sessions with SWL may be needed. PCNL has similar recommendation grade.</td>
</tr>
<tr>
<td>Pelvis &gt; 20 mm</td>
<td>PCNL</td>
<td>2</td>
<td>B</td>
<td>SWL/Open</td>
<td>Multiple sessions with SWL may be needed.</td>
</tr>
<tr>
<td>Lower pole calyx &lt; 10 mm</td>
<td>SWL</td>
<td>2</td>
<td>B</td>
<td>RIRS/PCNL/MicroPerc</td>
<td>Anatomical variations are important for complete clearance after SWL.</td>
</tr>
<tr>
<td>Lower pole calyx &gt; 10 mm</td>
<td>PCNL</td>
<td>2</td>
<td>B</td>
<td>SWL/MicroPerc</td>
<td>Anatomical variations are important for complete clearance after SWL.</td>
</tr>
<tr>
<td>Upper ureteric stones</td>
<td>SWL</td>
<td>2</td>
<td>B</td>
<td>PCNL/URS/Open</td>
<td>Additional intervention need is high with SWL.</td>
</tr>
<tr>
<td>Lower ureteric stones</td>
<td>URS</td>
<td>1</td>
<td>A</td>
<td>SWL/Open</td>
<td></td>
</tr>
<tr>
<td>Bladder stones</td>
<td>Endoscopic</td>
<td>2</td>
<td>B</td>
<td></td>
<td>Open is easier and with less operative time with large stones.</td>
</tr>
</tbody>
</table>

* Cystine and uric acid stones excluded. PCNL = percutaneous nephrolithostomy; SWL = shock-wave lithotripsy; RIRS = retrograde intrarenal surgery; URS = ureteroscopy.
## Conclusion

<table>
<thead>
<tr>
<th>Conclusions</th>
<th>LE</th>
</tr>
</thead>
<tbody>
<tr>
<td>The incidence of stone disease in children is increasing.</td>
<td>2</td>
</tr>
<tr>
<td>Any child with urinary stone disease deserves metabolic and anatomical evaluation.</td>
<td>2</td>
</tr>
<tr>
<td>Treatment should be supported with medical treatment for the underlying metabolic abnormality if detected.</td>
<td>1</td>
</tr>
<tr>
<td>Open surgery for stone disease in children is an exceedingly rare requirement.</td>
<td>1</td>
</tr>
<tr>
<td>Surgical treatment is based on minimally invasive modalities.</td>
<td>1</td>
</tr>
</tbody>
</table>

## Recommendations

<table>
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<tr>
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<th>LE</th>
<th>GR</th>
</tr>
</thead>
<tbody>
<tr>
<td>In most cases, plain abdominal X-ray and ultrasonography is sufficient for diagnosis and follow-up.</td>
<td>2</td>
<td>B</td>
</tr>
<tr>
<td>Non-contrast CT may be required in cases with a doubtful diagnosis or complex cases requiring surgery.</td>
<td>2</td>
<td>B</td>
</tr>
<tr>
<td>The use of appropriately-sized instruments will decrease the number of complications in surgical treatment.</td>
<td>1</td>
<td>A</td>
</tr>
</tbody>
</table>
THANK YOU