Pediatric Urolithiasis

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Incidence and Location of Stones

- There has been a great increase in recent years in stone incidence in adults and children*

- Stones are detected almost exclusively in the kidneys/ureters (not bladder)

*VanDervoot, J. Urol 2007;177:2300

And the reason?

- Improvement in imaging studies (CT)
  a. Old way – admit, scratch your head, IVP, etc. (and at times the pain resolved on its own)
  b. New way – CT, stone, fluids +pain killers+ alpha-blockers, home*

- A genuine increase in incidence
  The vast majority of stones (>95%) in children are made of calcium (oxalate or and phosphate)

* Nowadays more children with stones are discharged from the ER than treated on the floor

Calcium Stones - Etiologies

Promoters – excess
- Hypercalciuria
- Hyperoxaluria
- Hyperuricosuria
- pH
- Anatomic abnormalities

Inhibitors – deficiency
- Urine volume/flow
- Citrate
- Mg

Increasing Incidence of Pediatric Urolithiasis
The Scientific Proof

AP, Kansas City Star, March 27, 2009

Increasing Incidence of Kidney Stones in Children Evaluated in the ED (Charleston SC)

Sas DJ, J. Pediatr 2010

CMH, November 2010
Hypercalciuria (Ca>4.0 mg/kg/24h or Ca/creatinine >0.20): Etiologies

- Absorptive
- Renal
- Resorptive

or/and
- Genetic
- Acquired

Acquired Hypercalciuria

- Diseases – hypercalcemic states, metabolic bone diseases, immobilization
- Medications – corticosteroids, loop diuretics, vitamin D, antacids, theophylline, cephalosporins, Gentamicin
- Nutrition

Kidney Stone Disease and Obesity

- Two studies in adults showed stones to be twice as common in obese (BMI >30) compared with non-obese (4.6% vs. 2.6%) (JAMA 2005;293:455, J. Urol 2010;183:571)

Is this the case also in children?

Nutrition and Hypercalciuria

- Calcium - neutral
- Sodium – bad
- Potassium - good

- Fluids – very good
  a. lower urine calcium concentration
  b. Universal treatment and at times the only treatment of kidney stone disease

Percentage of Overweight Children in our Urolithiasis Population (n = 139)

<table>
<thead>
<tr>
<th>BMI &gt; 95</th>
<th>BMI &gt; 85</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male (n=65)</td>
<td>26.15</td>
</tr>
<tr>
<td>Female (n=74)</td>
<td>10.81</td>
</tr>
<tr>
<td>Both Sexes (n=139)</td>
<td>16.91</td>
</tr>
</tbody>
</table>

Stones in children are mostly composed of CaOx and CaP

“Oliguria” – The Mother of All Stones

24-h urine volume in pediatric stone formers < controls

A 13 y (40 kg) girl presented with severe left flank pain

Note the acoustic shadow on the left and orange “comet tail” on the right
“Oliguria” – The Mother of All Stones

Her 24-h urine had normal amounts of calcium, citrate, oxalate, uric acid. However, note urine volumes!!

Urine Volume and CaOx Supersaturation

Battino BS, J.Urol 2002;168;2568

Battino BS, J.Urol 2002;168;2568

Urine flow required to maintain calcium in a soluble state

This means that our patient needs to have UO >960 ml/24h

Urine SG in Children with Urolithiasis

Physicians vs pediatric urologists and nephrologists
Study = 32 pediatric urolithiasis
Control = 32 age-matched

Types of Drinks

Curhan, Kidney Int. 2001:59:2290

Effect of Climate on Urolithiasis

- Low urine output: another untoward result of global warming?

- It is anticipated that the incidence of urolithiasis in mid-continent USA will continue to rise as temperatures rise.

- $1^\circ$C = 1,000,000 cases

Predicted changes in stone risk by 2050
(increase by 1c = 1,000,000 additional patients)

The good news: Decreased rate of urolithiasis among American soldiers in Iraq once
forced hydration of troops in the field was ordered (Urology 74:58, 2009)

Calcium – should we recommend lower intake?

Low dietary calcium increases oxalate absorption in the gut,
and this diet is bad for the bones as well – thus the answer is no!
NEJM ED 2002;346:77-84

Sodium- Effect of Dietary NaCl Intake on Urine Calcium

Urine Ca and Na correlation in healthy and hypercalciuric children (n=100)

Osorio, Pediatrics 1997;100:675

Urine Ca and K correlation in healthy and hypercalciuric children

Urine Ca correlation with Na/K ratio

Osorio, Pediatrics 1997;100:675*
Effect of potassium supplementation on urine calcium in hypercalciuric children

- Osorio, Pediatrics 1997;100:675

Effect of a high salt load, before and after supplemental potassium citrate, on 24-hr urine calcium excretion in postmenopausal women

- N=52, 26 each group
- Low salt regimen provided 87 mmol (5 g) salt/day
- High salt 225 mmol (13.2 g)/day
- The potassium supplement provided 90 mmol (29.2 g) potassium citrate/day
- Rise in UCa on the high salt regimen vs. low salt was highly significant (P < 0.005)
- Difference in UCa change between high salt without K (42 ±12 mg/d) 33% vs. high salt with K (-8± 14 mg/d) 4% was highly significant (P=0.008)

Effect of dietary intervention (low Na/high K) on urine Na/K and Ca/creatinine ratios in pediatric calcium stone formers

- Pediatric Nephrology 2000;14:1011

Hypercalciuric Stones
Nutritional Management

- RDA protein
- RDA calcium
- Low (RDA) sodium (<2300 mg/day) (Big Mac 1040 mg, Taco salad 1780 mg, Yogurt 6oz 100 mg)
- High (RDA) potassium (3000 – 3500 mg/day) (5-6 servings of fruit and vegetable + dairy products)
- Maintaining urine Na/K <2.5

Effect of dietary potassium on urine citrate

- Kidney Int. 2004;66:2402

Hypocitraturia

- After urine flow, citrate is regarded as the 2nd important inhibitor of calcium stone formation
- Hypocitraturia can be secondary (gut problems) but in most stone formers it is idiopathic
- Problem – definition of hypocitraturia in children
Definition of Hypocitraturia

Urine Citrate/Creatinine Distribution in 149 Healthy School-age Children

5% at 179 mg/g

Srivastava, Pediatr Res, July 2009

Relative values of metabolic indices in pediatric stone formers

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<th>Pediatric stone formers</th>
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<tbody>
<tr>
<td>Ca/citrate ratio</td>
<td>0.17±0.17</td>
</tr>
<tr>
<td>Urine Ca/Cr</td>
<td>0.80±0.75</td>
</tr>
<tr>
<td>Urine Citrate/Cr</td>
<td>0.86±0.81</td>
</tr>
<tr>
<td>Urine Ca/Citrate</td>
<td>0.65±0.46</td>
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Srivastava, Pediatr Res, July 2009

Clinical Use of Ca/Citrate Ratio

Receiver operating characteristic curve (ROC) for Ca/Citrate between control and stone-formers, showing AUC of 0.933 for 0.33 mg/mg

Srivastava, Pediatr Res, July 2009

Urine Ca/Bl, Citrate/Bl and Ca/Citrate in Controls vs. hypercalciuric children w/o/w stones (or why don’t all hypercalciuric children develop stones?)

Controls 149

Hypercalciuric non-stone formers 78

Hypercalciuric stone formers 34

Calcium/Citrate Ratio

Calcium/Creatinine Ratio

Srivastava, Pediatr Res, July 2009

24-h urine chemistries before and after nutritional intervention in a 9 year old child with urolithiasis

Srivastava, Pediatr Res, July 2009
Hypercalciuric stones – Citrate Supplementation
(When diet alone is not enough)

- K-Citrate 0.5–2.0 mEq K/kg/day divided 2–3 doses*
  [Now also the treatment of choice in children on ketogenic diet (Pediatrics July;2009)]

- Besides urine Ca, follow Na, K, citrate and SG

- Check urine pH, if >7.4 there may be a risk of promoting CaP precipitation

* By now you understand why K-citrate and not Na-citrate

Effect of Medical Treatment on Stone Recurrence in Adults (n = 70)
(or in other words – medical treatment works)

<table>
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<th>Table 4. SFR before and after PNL</th>
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<tr>
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<tr>
<td>Prop SFR</td>
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<tr>
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* Wilcoxon signed rank test.


Idiopathic Calcium Stones
Principles of Management

- High fluid intake (urine SG <1.010)
- No room for calcium restriction
- Healthy nutrition
- Follow-up urine chemistries + imaging
- If needed, K-citrate or and thiazides/amiloride

A bonus - Effect of substituting dietary Na by K on cardiovascular mortality - adults

DASH = Dietary Approach to Stop Hypertension

The Original DASH Diet

DASH eating pattern per day:

- Vegetables (four to five servings)
- Fruit (four to five servings)
- Low-fat or fat-free dairy foods (two to three servings)
- Lean meats, poultry, and fish (one or two servings)
- Grains and grain products (seven to eight servings)
- Nuts, seeds, and dry beans (four to five servings/week)
- Sweets (added sugars; five servings/week)
The DASH diet is high in calcium, potassium and fiber, and low in fat and sodium.

In 45,821 men the relative risk for urolithiasis was 0.58 (JASN 20:2253, 2009).

Daily Fruit and Vegetable Consumption in School-Age Children

A walking school bus program


Idiopathic Calcium Stones
The Take Home Message

- In essence we are talking preventive medicine
- High fluid intake
  Urolithiasis is the only “kidney disease” needing high fluid intake
  “The urine should look like water”
- Healthy nutrition (better term than diet)
  Best if the whole family participates
  Continue lobbying the food industry to ↓ Na
  Push for more fruits and vegetables

End

Thank you for your attention

Declaration of Conflict of Interests:
My grandfather was a greengrocer

Effect of Medical Treatment on Stone incidence (adults)

Parks JH, Coe FL, BJU Int. 103:1246, 2009

Ureteral stone location at ED presentation with colic (adults)

Eisman BHR, J Urol 182:165, 2009
Percentage of Overweight Children in our Urolithiasis Population (1)

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<th>Percent</th>
<th>CI</th>
<th>BMI &gt; 95 Locally</th>
<th>BMI &gt; 95 Nationally</th>
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</thead>
<tbody>
<tr>
<td>Both Sexes</td>
<td>14.1</td>
<td>14.1--19.6</td>
<td>16.9</td>
<td>16.9--24.37</td>
</tr>
<tr>
<td>Male</td>
<td>17.0</td>
<td>17.0--22.8</td>
<td>16.9</td>
<td>16.9--24.37</td>
</tr>
<tr>
<td>Female</td>
<td>10.9</td>
<td>10.9--15.9</td>
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Why nephrologists (and other good doctors) don’t like the Atkin’s diet

To buffer the nutritional acid load caused by eating (animal) proteins, bone resolves to supply HCO3-, but with it excess calcium is released from bone.

JCI 1974;26:315