Kidney Stones: Diagnosis, Treatment, & Future Prevention

Jessica Corean, MD
PGY 3
Anatomic and Clinical Pathology Resident
University of Utah CME statement

• The University of Utah School of Medicine adheres to ACCME Standards regarding industry support of continuing medical education.

• Speakers are also expected to openly disclose intent to discuss any off-label, experimental, or investigational use of drugs, devices, or equipment in their presentations.

• The speaker has nothing to disclose.
Learning Objectives

1. Describe the clinical presentation, laboratory, and radiographic findings of an individual affected by a kidney stone.
2. Compare 3 composition types of kidney stones and their clinical management.
3. Differentiate spontaneous and familial risk factors for kidney stone development.
Outline

- Case-based Approach:
  - Diagnosis of a Kidney Stone
  - Epidemiology
  - Pathogenesis
  - Risk Factors
  - Management
  - Further Work-up
  - Prevention
  - Complications
Case #1: 38 year old male

- Flank pain
  - Acute, colicky
  - Radiating to pelvis and genitalia
- Nausea and vomiting
- Urinary urgency, frequency, and dysuria
- This has happened once before...

http://www.md-health.com/Kidney-Stones.html
Differential Diagnosis

- Urinary tract infection
- Musculoskeletal pain
- Groin hernia
- Acute pyelonephritis
- Prostatitis

- Women:
  - Ectopic Pregnancy
  - Ovarian torsion
  - Ovarian cyst rupture
Indications for testing:

*Flank pain, Nausea & vomiting, and/or symptoms of a stone*

1. Order: Urinalysis
2. Hematuria
3. Imaging
4. Strain urine and stone analysis
   - If second stone, consider 24 hour urine
Emergency Department Work-Up

- Complete blood count
- Comprehensive metabolic panel
- Urinalysis
- Imaging
## CBC Normal Values for Adult Male

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>RBC</td>
<td>4.7-6.4 M/uL</td>
</tr>
<tr>
<td>WBC</td>
<td>4.5-11K/uL</td>
</tr>
<tr>
<td>Hgb</td>
<td>14-18 g/dL</td>
</tr>
<tr>
<td>Hct</td>
<td>40-50%</td>
</tr>
<tr>
<td>MCV</td>
<td>78-98 fL</td>
</tr>
<tr>
<td>MCH</td>
<td>27-35pg</td>
</tr>
<tr>
<td>MCHC</td>
<td>31-37%</td>
</tr>
<tr>
<td>Neutrophils</td>
<td>50-81%</td>
</tr>
<tr>
<td>Bands</td>
<td>1-5%</td>
</tr>
<tr>
<td>Lymphocytes</td>
<td>14-44%</td>
</tr>
<tr>
<td>Monocytes</td>
<td>2-6%</td>
</tr>
<tr>
<td>Eosinophils</td>
<td>1-5%</td>
</tr>
<tr>
<td>Basophils</td>
<td>0-1%</td>
</tr>
<tr>
<td>Test</td>
<td>Value</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>Glucose</td>
<td>65-100 mg/dL</td>
</tr>
<tr>
<td>BUN</td>
<td>8-25 mg/dL</td>
</tr>
<tr>
<td>Creatinine</td>
<td>0.6-1.3 mg/dL</td>
</tr>
<tr>
<td>EGFR</td>
<td>&gt;60 ml/min/1.73</td>
</tr>
<tr>
<td>Sodium</td>
<td>133-146 mmol/L</td>
</tr>
<tr>
<td>Potassium</td>
<td>3.5-5.3 mmol/L</td>
</tr>
<tr>
<td>Chloride</td>
<td>97-110 mmol/L</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>18-30 mmol/L</td>
</tr>
<tr>
<td>Calcium</td>
<td>8.5-10.5 mg/dL</td>
</tr>
<tr>
<td>Protein, total</td>
<td>6.0-8.4 g/dL</td>
</tr>
<tr>
<td>Albumin</td>
<td>2.9-5.0 g/dL</td>
</tr>
<tr>
<td>Bilirubin, total</td>
<td>0.1-1.3 mg/dL</td>
</tr>
<tr>
<td>Alkaline phosphatase</td>
<td>30-132 U/L</td>
</tr>
<tr>
<td>AST</td>
<td>5-35 U/L</td>
</tr>
<tr>
<td>ALT</td>
<td>7-56 U/L</td>
</tr>
<tr>
<td>Parameter</td>
<td>Color Code</td>
</tr>
<tr>
<td>-----------------</td>
<td>------------</td>
</tr>
<tr>
<td>Leukocytes 120s</td>
<td>Neg.</td>
</tr>
<tr>
<td>Nitrite 60s</td>
<td>Neg.</td>
</tr>
<tr>
<td>Urobilinogen 60s</td>
<td>3.2</td>
</tr>
<tr>
<td>Protein 60s</td>
<td>5.0</td>
</tr>
<tr>
<td>pH 60s</td>
<td>6.0</td>
</tr>
<tr>
<td>Blood 60s</td>
<td>Neg.</td>
</tr>
<tr>
<td>Specific Gravity45s</td>
<td>1.000</td>
</tr>
<tr>
<td>Ascorbate 40s</td>
<td>Neg.</td>
</tr>
<tr>
<td>Ketone 40s</td>
<td>Neg.</td>
</tr>
<tr>
<td>Bilirubin 30s</td>
<td>Neg.</td>
</tr>
<tr>
<td>Glucose 30s</td>
<td>Neg.</td>
</tr>
</tbody>
</table>

- **Leukocytes**: Neg., Trace 15, Small 70, Moderate 125, Large 500, **cells/μl**
- **Nitrite**: Neg., Any degree of uniform pink color, **μmol/l**
- **Urobilinogen**: Normal, Trace 10, Hemolyzed 25, **μmol/l**
- **Protein**: Normal, Trace 0.3, Small 1.0, Moderate 3.0, Large 20.0, **g/l**
- **Blood**: Neg., Non-hemolyzed Trace 10, Hemolyzed 25, Moderate 80, Large 200, **cells/μl**
- **Specific Gravity**: 1.000, 1.005, 1.010, 1.015, 1.020, 1.025, 1.030, **mmol/l**
- **Ascorbate**: Neg., Trace 0.6, Small 1.4, Moderate 2.8, Large 5.0, **mmol/l**
- **Ketone**: Neg., Trace 0.5, Small 1.5, Moderate 4.0, Large 8.0, **mmol/l**
- **Bilirubin**: Neg., Trace 0.5, Small 1.7, Moderate 5.0, Large 10.0, **μmol/l**
- **Glucose**: Neg., Trace 0.5, Small 15, Moderate 30, Large 60, **mmol/l**

UA Findings

- Hematuria, microscopic
  - Small amount of blood in urine
    - Still yellow in color
  - Single, most discriminating predictor of kidney stone if patient presents with unilateral flank pain
    - Present in 95% of patients on Day #1
    - Present in 65-68% of patients on Day #3 or #4
Kidney Anatomy

- Arcuate blood vessels
- Minor calyx
- Major calyx
- Renal pelvis
- Pyramid
- Papilla
- Renal column
- Cortex
- Renal vein
- Renal artery
- Renal nerve
- Renal hilum
- Medulla
- Ureter
- Capsule

Imaging

- Non-contrast helical CT
  - More sensitive (88%)
  - Radiation exposure, cumulative

- Ultrasonography
  - At bedside (54-57%)
  - No radiation
Epidemiology

- 1-5/1000 incidence
  - Approximately 1/11 affected in lifetime
  - Increased from 3.8% in 1970s to 8.8% in 2000s
- Peak incidence in 20s
  - Caucasian men
- Male > Female (2-3:1)
- Geography:
  - Hotter and drier climates
Pathogenesis Theory #1

- Normally soluble material supersaturates within the urine and begins process of crystal formation.
- Becomes anchored at damaged epithelial cells.
Pathogenesis Theory #2

- Initiated in renal medullary then extruded into renal papilla.
- Acts as a nidus for further deposition.

[Diagram of kidney structures with labels: Bowman's capsule, Juxtamedullary nephron, Cortical nephron, glomerulus, Renal cortex, Renal medulla, Collecting duct, To renal pelvis.]

[Link: http://bio1152.nicerweb.com/Locked/media/ch44/nephron.html]
Risk Factors

- Urine composition
- Prior kidney stones
- Family history of kidney stones
- Enhanced enteric oxalate absorption
- Frequent upper urinary tract infections
- Hypertension
- Low fluid intake
- Acidic urine
Management and Treatment
Management of acute symptomatic nephrolithiasis

- Symptomatic ureteral stone (non-contrast renal CT)
  - Pain control
  - Urosepsis?
    - No
      - Stone >10 mm
        - No
        - Yes
    - Yes
      - Emergent decompression (ureteral stent or nephrostomy tube)
Observation, treat symptoms, α-blocker, strain urine

Stone passes

Yes → Evaluate and treat underlying cause of stone disease

No → Urologic evaluation

Urologic evaluation → ESWL or URS

Evaluate and treat underlying cause of stone disease
Conservative Management

- Hydration
- Pain management
- Alpha blockers
- Strain/filter urine
Aggressive Management

- Extracorporeal shock wave lithotripsy
- Ureterorenoscopic manipulation
- Open or laparoscopic surgery
- Decompression
  - Ureteral stent
  - Nephrostomy tube
Aggressive Management

(ESWL)

Extracorporeal Shock Wave Lithotripsy

Lithotripter

Beam shock waves

Kidney stones

Focused shock waves

Kidney stones crushed

Further Work-up

- Chemistry panel
  - If serum calcium high-normal, then test parathyroid hormone concentration

- Stone analysis

- 24 hour urine
  - Measured 2-3 times
  - Wait 1-3 months after acute episode
Stone analysis

- Collect information from the stone to establish cause(s) of stone formation and growth
- Identify possible underlying metabolic disorders
- Guide preventative therapy
Types of Stones

- Calcium stones
  - Calcium oxalate (~80%)
  - Calcium phosphate (~5-10%)
- Struvite stones (~10-15%)
  - Magnesium ammonium phosphate hexahydrate
- Uric acid stones (~5-10%)
- Cystine stones (~1-2%)
- Combination
Stone Analysis Testing Methods

- Chemical methods
  - Destructive and need several mg of sample
  - Cannot distinguish mineral constituents (with similar chemical composition)

- Physical methods
  - Need less sample
  - Distinguish different minerals within one stone
Physical methods

- X-ray diffraction (XRD)
- Fourier transform infrared spectroscopy
Fourier Transform Infrared Spectroscopy

1. Crush into a powder
2. Infrared beam passes through powder
3. Molecular bonds within powder absorb portion of radiation giving a unique spectra

http://www.kwipped.com/rentals/laboratory/infrared-spectrometers/479
Spectrum

Calcium Oxalate Monohydrate (5)
Stone Analysis

- Calcium oxalate monohydrate
  - Ca(COO)₂·H₂O (Whewellite)
24 Hour urine collection

- Measure:
  - Volume
  - pH
  - Calcium
  - Uric acid
  - Citrate
  - Oxalate
  - Sodium
  - Creatinine

https://www.youtube.com/watch?v=BLqSNibwV5g
What is a supersaturation profile?

- Urine frequently supersaturated, favoring precipitation of crystals
  - Balanced by crystallization inhibitors: ions (citrate) and macromolecules
- Measure ion concentration
- Computer program can calculate theoretical supersaturation risk with respect to specific crystalline phases
<table>
<thead>
<tr>
<th>Component</th>
<th>Calculated Risk</th>
<th>Relative Supersaturation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium Oxalate</td>
<td>3.93</td>
<td></td>
</tr>
<tr>
<td>Calcium Hydrogen Phosphate</td>
<td>3.78</td>
<td></td>
</tr>
<tr>
<td>Uric Acid</td>
<td>0.05</td>
<td></td>
</tr>
</tbody>
</table>

Calculated risk is derived by a computer program that models the thermodynamics of calculi formation using measured urine components.

## Component Results

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Result</th>
<th>Units</th>
<th>Reference Interval</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Volume</td>
<td>3600</td>
<td>mL</td>
<td></td>
<td>Low urine volume (&lt;1L/24h) promotes calculi formation.</td>
</tr>
<tr>
<td>pH</td>
<td>6.94</td>
<td></td>
<td>5.00-7.50</td>
<td>Acidic urine (pH&lt;5.5) promotes precipitation of UrA. Alkaline urine (pH&gt;7.2) promotes formation of CaHPO4 stones.</td>
</tr>
<tr>
<td>Calcium</td>
<td>457</td>
<td>mg/d</td>
<td></td>
<td>Hypercalcuiura (&gt;200 mg/d) promotes formation of CaOx and CaHPO4 stones.</td>
</tr>
<tr>
<td>Oxalate</td>
<td>43</td>
<td>mg/d</td>
<td>16-49</td>
<td>Hyperoxaluria (&gt;40 mg/d) promotes formation of CaOx stones.</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>1152</td>
<td>mg/d</td>
<td>400-1300</td>
<td>Forms insoluble complexes with calcium.</td>
</tr>
<tr>
<td>Sodium</td>
<td>306</td>
<td>mmol/d</td>
<td>51-286</td>
<td>Increased sodium promotes formation of CaOx and CaHPO4 stones.</td>
</tr>
<tr>
<td>Sulfate</td>
<td>32</td>
<td>mmol/d</td>
<td>6-30</td>
<td>Normal to high sulfate promotes precipitation of CaOx and CaHPO4 stones.</td>
</tr>
<tr>
<td>Urate</td>
<td>839</td>
<td>mg/d</td>
<td>250-750</td>
<td>Hyperuricosuria (&gt;600 mg/d) promotes formation of UrA stones.</td>
</tr>
<tr>
<td>Citrate</td>
<td>1109</td>
<td>mg/d</td>
<td>320-1240</td>
<td>High citrate inhibits formation of CaOx and CaHPO4 stones.</td>
</tr>
<tr>
<td>Magnesium</td>
<td>238</td>
<td>mg/d</td>
<td>12-199</td>
<td>High magnesium inhibits formation of CaOx and CaHPO4 stones.</td>
</tr>
<tr>
<td>Potassium</td>
<td>140</td>
<td>mmol/d</td>
<td>25-125</td>
<td>Forms soluble complexes and inhibits stone formation.</td>
</tr>
<tr>
<td>Chloride</td>
<td>238</td>
<td>mmol/d</td>
<td>140-250</td>
<td>Forms soluble complexes and inhibits stone formation.</td>
</tr>
<tr>
<td>Creatinine</td>
<td>1548</td>
<td>mg/d</td>
<td>800-2100</td>
<td>Excretion provides a measure of completeness of 24h urine collection.</td>
</tr>
</tbody>
</table>
### Calculus

<table>
<thead>
<tr>
<th>Component</th>
<th>Calculated Risk</th>
<th>Relative Supersaturation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium Oxalate</td>
<td>6.93</td>
<td>Reduced Risk &lt; 5</td>
</tr>
<tr>
<td>Calcium Hydrogen Phosphate</td>
<td>0.16</td>
<td>Reduced Risk &lt; 2</td>
</tr>
<tr>
<td>Uric Acid</td>
<td>1.63</td>
<td>Reduced Risk &lt; 1</td>
</tr>
</tbody>
</table>

Calculated risk is derived by a computer program that models the thermodynamics of calculi formation using measured urine components.

### Component Results

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Result</th>
<th>Units</th>
<th>Reference Interval</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Volume</td>
<td>881</td>
<td>mL</td>
<td></td>
<td>Low urine volume (&lt;1L/24h) promotes calculi formation.</td>
</tr>
<tr>
<td>pH</td>
<td>5.17</td>
<td></td>
<td>5.00-7.50</td>
<td>Acidic urine (pH&lt;5.5) promotes precipitation of UrA. Alkaline urine (pH&gt;7.2) promotes formation of CaHPO4 stones.</td>
</tr>
<tr>
<td>Calcium</td>
<td>67</td>
<td>mg/d</td>
<td></td>
<td>Hypercalciuria (&gt;200 mg/d) promotes formation of CaOx and CaHPO4 stones.</td>
</tr>
<tr>
<td>Oxalate</td>
<td>27</td>
<td>mg/d</td>
<td>16-49</td>
<td>Hyperoxaluria (&gt;40 mg/d) promotes formation of CaOx stones.</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>335</td>
<td>mg/d</td>
<td>400-1300</td>
<td>Forms insoluble complexes with calcium.</td>
</tr>
<tr>
<td>Sodium</td>
<td>59</td>
<td>mmol/d</td>
<td>51-286</td>
<td>Increased sodium promotes formation of CaOx and CaHPO4 stones.</td>
</tr>
<tr>
<td>Sulfate</td>
<td>7</td>
<td>mmol/d</td>
<td>6-30</td>
<td>Normal to high sulfate promotes precipitation of CaOx and CaHPO4 stones.</td>
</tr>
<tr>
<td>Urate</td>
<td>263</td>
<td>mg/d</td>
<td>250-750</td>
<td>Hyperuricosuria (&gt;800 mg/d) promotes formation of UrA stones.</td>
</tr>
<tr>
<td>Citrate</td>
<td>309</td>
<td>mg/d</td>
<td>320-1240</td>
<td>High citrate inhibits formation of CaOx and CaHPO4 stones.</td>
</tr>
<tr>
<td>Magnesium</td>
<td>50</td>
<td>mg/d</td>
<td>12-199</td>
<td>High magnesium inhibits formation of CaOx and CaHPO4 stones.</td>
</tr>
<tr>
<td>Potassium</td>
<td>22</td>
<td>mmol/d</td>
<td>25-125</td>
<td>Forms soluble complexes and inhibits stone formation.</td>
</tr>
<tr>
<td>Chloride</td>
<td>51</td>
<td>mmol/d</td>
<td>140-250</td>
<td>Forms soluble complexes and inhibits stone formation.</td>
</tr>
<tr>
<td>Creatinine</td>
<td>722</td>
<td>mg/d</td>
<td>800-2100</td>
<td>Excretion provides a measure of completeness of 24h urine collection.</td>
</tr>
</tbody>
</table>
Case Wrap-Up and Prevention

- All stones: maintain urine volume >2.5L/day
- Our patient had a calcium oxalate stone
- Recommendations:
  - Reduce soft drink intake
  - Thiazide diuretics
  - Citrate pharmacotherapy (lower urinary citrate)
  - Reduce sodium and animal protein
  - Limit oxalate and eat more dairy (if oxalate high)
Complications

- Can lead to persistent renal obstruction
  - Permanent renal damage or renal failure
Case #2: 27 year old female

- Mild dysuria for a few weeks
- Mild flank pain, which has intensified over the last 24 hours

Emergency Department Work-up:
- Complete Blood Count
- Complete Metabolic Panel
- Urinalysis with Culture
- Imaging
<table>
<thead>
<tr>
<th>Female Complete Blood Count</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RBC</strong></td>
</tr>
<tr>
<td><strong>WBC</strong></td>
</tr>
<tr>
<td><strong>Hgb</strong></td>
</tr>
<tr>
<td><strong>Hct</strong></td>
</tr>
<tr>
<td><strong>MCV</strong></td>
</tr>
<tr>
<td><strong>MCH</strong></td>
</tr>
<tr>
<td><strong>MCHC</strong></td>
</tr>
<tr>
<td><strong>Neutrophils</strong></td>
</tr>
<tr>
<td><strong>Bands</strong></td>
</tr>
<tr>
<td><strong>Lymphocytes</strong></td>
</tr>
<tr>
<td><strong>Monocytes</strong></td>
</tr>
<tr>
<td><strong>Eosinophils</strong></td>
</tr>
<tr>
<td><strong>Basophils</strong></td>
</tr>
</tbody>
</table>
**Urinalysis findings: Struvite**

- **Microscopic hematuria**
- **Elevated:**
  - Leukocyte esterase
  - White blood cells
  - Bacteria
- **Crystals**
  - Coffin lid appearance
  - Typically in alkaline urine

[Image of coffee with a hand waving]
Imaging

- Very dramatic
- Can block entire renal calyces
Spectrum
Struvite

Length 7.9 mm
Epidemiology

- Approximately 10-15% of kidney stones
- Typically women (3:1)
  - Higher rates of urinary tract infections
Pathogenesis

- Formation occurs only when ammonia production increased and urine pH is elevated, i.e. by urease-producing organisms:
  - Proteus or Klebsiella
Risk Factors

- Urinary tract infections
  - Female
  - Neurogenic bladder
  - Urinary diversion
Management

- Most large staghorn calculi require surgical treatment
- Options:
  - Medical therapy alone
  - Open or laparoscopic surgery
  - Percutaneous nephrolithotomy
  - Shock-wave lithotripsy
Prevention

- Metabolic evaluation
  - Similar to other types of kidney stone formers

- Treat underlying medical issue
  - Urinary tract and/or kidney infection
Case #3: 7 year old girl

- Flank pain
- Abdominal pain

Preliminary Work-up:
- Complete Blood Count
- Complete Metabolic Panel
- Urinalysis with culture
- Imaging

http://www.sheknows.com/health-and-wellness/articles/814344/kids-kidney-stones-cases-on-the-rise-1
<table>
<thead>
<tr>
<th>Test</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>RBC</td>
<td>3.5-5.0 M/uL</td>
</tr>
<tr>
<td>WBC</td>
<td>4.5-11K/uL</td>
</tr>
<tr>
<td>Hgb</td>
<td>10-14 g/dL</td>
</tr>
<tr>
<td>Hct</td>
<td>30-42%</td>
</tr>
<tr>
<td>MCV</td>
<td>78-98 fL</td>
</tr>
<tr>
<td>MCH</td>
<td>27-35pg</td>
</tr>
<tr>
<td>MCHC</td>
<td>31-37%</td>
</tr>
<tr>
<td>Neutrophils</td>
<td>50-81%</td>
</tr>
<tr>
<td>Bands</td>
<td>1-5%</td>
</tr>
<tr>
<td>Lymphocytes</td>
<td>14-44%</td>
</tr>
<tr>
<td>Monocytes</td>
<td>2-6%</td>
</tr>
<tr>
<td>Eosinophils</td>
<td>1-5%</td>
</tr>
<tr>
<td>Basophils</td>
<td>0-1%</td>
</tr>
</tbody>
</table>
UA Findings

- Microscopic hematuria
- Crystals
  - Hexagonal crystals
Spectra

Cystine(7)

Wavenumber
Cystine
Pediatric Kidney Stones

- In a child or adolescent (<12 years old) with first stone, clinician should suspect cystinuria
Epidemiology of Cystinuria

- Cystine stones represent 1-2% of total kidney stones
  - In children, up to 5% of total kidney stones
- Cystinuria:
  - Autosomal recessive
  - Due to an inherited impairment of renal cystine transport
  - Males more severely affected than females
Pathogenesis

http://bio1152.nicerweb.com/Locked/media/ch44/nephron.html
https://www.researchgate.net/publication/5651534_Aminoacidurias_Clinical_and_molecular_aspects
Diagnosis

One or more of the following are required to diagnosis cystinuria:

1. Stone analysis showing cystine
2. Positive family history of cystinuria
3. Hexagonal cystine crystals on urinalysis (about 25% of patients)
Further Work-up

- Cyanide-nitroprusside screen
- Urinary cystine excretion (amino acid panel)
Management & Prevention

- Acute management
- Prevention:
  - Increase fluid intake
  - Reduce sodium and protein intake
  - Urinary alkalization
  - Medications
Management Monitoring

- 24 hour urine evaluation
  - Assess response (and adherence) to treatment
  - Measure urine volume, cystine, pH, creatinine, sodium, and calcium
  - Measure supersaturation risk of cystine
Retention Questions
1. Which type of kidney stone is the most common?

- a) Calcium
- b) Uric acid
- c) Cystine
- d) Cholesterol
2. Which of the following options outline conservative prevention strategies?

a) Surgery
b) Alpha blocker medication
c) Increase fluid intake
d) Increase sodium and animal protein intake
3. Which of the following is true?

a) All adults should have a full metabolic work-up with their first kidney stone.

b) All children should have a full metabolic work-up with their first kidney stone.

b* star icon

b) All children should have a full metabolic work-up with their first kidney stone.

c) Struvite stone formers do not need antibiotic treatment.

d) Kidney stones larger than 10mm usually pass spontaneously.
References

- ARUPConsult.com
- UpToDate.com