STONES
Dietary and Medical Therapy
Prevention
Adjuvant

Manoj Monga, MD
The Cleveland Clinic
Incidence and Prevalence

• Worldwide, 1 in 10 people experience a kidney stone in their lifetime

• Recurrence rates are high
  – 30% to 50% chance of developing another stone within 5 years
  – Average rate of new stone formation: 1 stone every 2 to 3 years

• Prevalence has increased
  – Faster rate of increase in women
EMPIRIC DIETARY TX

Conservative treatment plan

- High fluid intake (Ten 10-oz glasses)
- Dietary sodium restriction (1500 mg/day)
- Dietary citrate (4oz concentrated lemon/lime)
- Adequate calcium intake
  - 2 to 3 dairy servings per day
  - 1200 mg daily
Fluids
Target – 2L of urine
5-year follow-up

Stone Recurrence (%)

Time to Recurrence (months)

J Urol 155: 839, 1996
Fluids

- Low fluid intake $\rightarrow$ low urine output and slow rate of urine flow

- What fluids are recommended?
  - Nearly all beverages are protective
    - Includes coffee (reg or decaf), tea, wine, beer…
    - Fruit juices, in moderation, recommended for high potassium and citric acid content
  - A few beverages not protective
    - Tomato juice: High sodium content
    - Grapefruit juice: High oxalate
    - Cranberry juice: Acidifies urine and increases urinary oxalate
Citrate Effect on Lithogenesis

Supersaturation

Nucleation and growth

Binds ionic Ca

Inhibits spontaneous and heterogeneous Nucleation

Growth and aggregation

Retards agglomeration of preformed CaOx crystals and inhibits crystal growth of CaP

Membrane molecules exposed

Crystal-cell binding

Renal stone

Modified: courtesy of Kris Penniston PhD
Lemon Juice 4 oz / day

![Graph showing changes in Citrate and Oxalate before and after lemon juice consumption.](image)

- Citrate: Before = 200 mg/day, After = 350 mg/day
- Oxalate: Before = 50 mg/day, After = 50 mg/day

Statistical significance:
- Citrate: $P < 0.001$
- Oxalate: Change NS (Not Significant)

Dietary Citrate

- **CITRIC ACID**
  - Lemon
  - Lime

- **POTASSIUM CITRATE**
  - Melon
  - Tomato

↑ Citrate  ↑ pH  ↑ K+
Soft Drinks
Soda
Pop

• Phosphoric acid acidifies urine increased stone risk?

J Clin Epidemiol 45: 911-16, 1992
Type of Soda – what happens when you stop?

- Control
- Phosphoric acid
- Citric acid

Stone recurrence rate (%)

<table>
<thead>
<tr>
<th></th>
<th>&gt;160 ml/day</th>
<th>Abstain</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;160 ml/day</td>
<td>50</td>
<td>20</td>
</tr>
<tr>
<td>Abstain</td>
<td>40</td>
<td>30</td>
</tr>
</tbody>
</table>

Schuster, 1992
Limit Calcium

• Low dietary calcium increases risk of symptomatic kidney stones

NEJM 328: 833-8, 1993
Ann Int Med 126: 553-5, 1997
NEJM 346: 77-84, 2002
Sources of Calcium

- Dairy products
- Fortified foods
  - orange juice, soy milk, tofu, selected cereals
- Sardines with bones
- Almonds
- Bok choy, turnip greens, kale
- Calcium supplements
<table>
<thead>
<tr>
<th>Calcium-rich foods</th>
<th>Food item</th>
<th>1 serving</th>
<th>Calcium content (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low-fat yogurt</td>
<td>1 cup (8 oz)</td>
<td>415</td>
</tr>
<tr>
<td></td>
<td>Milk (whole, low-fat, skim, or chocolate)</td>
<td>1 cup (8 oz)</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>Red salmon</td>
<td>½ cup (3½ oz)</td>
<td>259</td>
</tr>
<tr>
<td></td>
<td>Cheddar cheese</td>
<td>1 slice (1 oz)</td>
<td>204</td>
</tr>
</tbody>
</table>
Salt

• Every 2300 mg of Salt (one teaspoon)

• 23 mg increase in urinary calcium

• higher rates of bone resorption
• effect greater if low dietary calcium
• decreases urinary citrate 20%

J Urol 150: 310, 1993
Most Sodium Comes from Processed and Restaurant Foods

- Processed and restaurant foods: 77%
- Naturally occurring: 12%
- While eating: 6%
- Home cooking: 5%
<table>
<thead>
<tr>
<th>Sodium-rich foods</th>
<th>Food item</th>
<th>1 serving</th>
<th>Sodium content (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pizza, cheese</td>
<td>½ of 10-inch pizza</td>
<td>1127</td>
</tr>
<tr>
<td></td>
<td>Soups, canned</td>
<td>1 cup</td>
<td>1081 avg (644-3864)</td>
</tr>
</tbody>
</table>
• 40% of American meals are eaten outside the home

[Sodium Facts, United States]

- Average daily sodium intake age 2 and up: 3,436 mg
- Tolerable Upper Intake Level: 2,300 mg
- Recommended Adequate Intake Level: 1,500 mg
- How much daily sodium our bodies need: 180–500 mg

Decreasing sodium intake could prevent thousands of deaths annually.^

^Because nearly 400,000 deaths each year are attributed to high blood pressure.
THE “5” RULE

If the word *salt* or *sodium* is in the first five ingredients on the food label DO NOT BUY!
SALT BY ANY OTHER NAME IS STILL SALT

SEA SALT
GARLIC SALT
ONION SALT
SEASONED SALT
MSG
EFFECT OF LOW SALT DIET ON IDIOPATHIC HYPERCALCIURI


62% normalized urinary calcium with sodium restriction
DIRECTED THERAPY

- URINALYSIS
- STONE COMPOSITION
- 24-HR URINE
URINE PH

CAOX  <5.5  URIC ACID
CAPH  >7.0  STRUVITE

Ideal pH is 5.8-6.2
SERUM

↑ Ca, ↓ P : Primary hyperparathyroidism

↓ K, ↓ CO₂ : RTA

↑ Uric Acid : Gouty diathesis
24 hr urine Metabolic Evaluation

RISK ASSESSMENT
First Episode

- Age < 20
- Family history of stones
- Bone/GI disease
- Gout
- Chronic UTI
- Nephrocalcinosis
- Obesity
- Type II diabetes
- Large/complex stones
- Specific stone composition (uric acid or cystine)

What is a recurrent stone former?
Passed multiple stones
Multiple stones on CT

95%

NO
Screening Evaluation
-Diet
-Mx
-UTI
-Fluids

YES
Standard Metabolic Evaluation (SME)
# UroRisk®

## Diagnostic Profile

<table>
<thead>
<tr>
<th>Metabolic</th>
<th>Environmental</th>
<th>Relative Supersaturation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca</td>
<td>Ox</td>
<td>UA</td>
</tr>
<tr>
<td>283</td>
<td>28</td>
<td>419</td>
</tr>
</tbody>
</table>

**mg/day** | **mg/day** | **mg/day** | **l/day** | **meq/day** | **mg/day** | **mg/day** | **mg/day** | **mg/day** | **mg/day** | **mg/day** | **mg/day** | **mg/day** |

**Other Values**

- **K**
  - 57 meq/day

- **Creatinine**
  - 1104 mg/day
PTH

• When to check PTH?
  – 2% of stone formers
  – 36% had NORMAL URINARY CALCIUM
  – Check everyone
    • Women 4.9 O.R.
      – Abstract 2222

• High PTH
  – Check 25-OH Vit D
    • 45% will be low
      – Abstract 2235
Fish Oil

- Cold water fish
- Eicosapentanoic acid (n-3 fatty acid)
- Competes with arachidonic acid (n-6)
- LESS PGE2
  - Less renal CA excretion
  - Activation of Na/K/Ca – more CA reabsorption
  - Decreased 1,25 Vitamin D levels
  - Decreased bone resorption
  - ? Impact on ureteral contractility in obstruction
Hypercalciuria: Omega 3 Fatty Acids

salmon, tuna, mackerel, sardines, walnuts, flax seeds, canola oil
Urinary CA
EPA 1800 mg for 18 months

Yasui et al
Urinary Citrate
EPA 1800 mg for 6 weeks

Ito et al
Thiazides

- Decrease urinary CA 20-30%
  - Distal Renal Tubule
  - Inhibit NA reabsorption, Increase CA reabsorption
- Increase Bone Mineral Density
- Ten randomized controlled studies
- *** monitor CA, K, UA, GLU***
- *** limit dietary sodium***
Indapamide
Urinary CA

J Cardiovasc Pharm  22 (Suppl 6: S78-S86, 1993
Indapamide
Stone-free at 3 years

P=.02

Diet and Fluids
Indapamide 2.5mg

J Cardiovasc Pharm 22 (Suppl 6: S78-S86, 1993)
AHRQ project

Thiazides and stone recurrence

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Thiazide</th>
<th>Control</th>
<th>Risk Ratio</th>
<th>Risk Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Events</td>
<td>Total</td>
<td>Events</td>
<td>Total</td>
</tr>
<tr>
<td>Ettinger 1988</td>
<td>6</td>
<td>42</td>
<td>14</td>
<td>31</td>
</tr>
<tr>
<td>Borghi 1993</td>
<td>6</td>
<td>43</td>
<td>9</td>
<td>21</td>
</tr>
<tr>
<td>Laerum 1984</td>
<td>5</td>
<td>23</td>
<td>12</td>
<td>25</td>
</tr>
<tr>
<td>Fernández-Rodriguez 2006</td>
<td>31</td>
<td>100</td>
<td>28</td>
<td>50</td>
</tr>
<tr>
<td>Ahlstrand 1996</td>
<td>9</td>
<td>17</td>
<td>19</td>
<td>22</td>
</tr>
<tr>
<td>Ala-Opas 1987</td>
<td>6</td>
<td>28</td>
<td>12</td>
<td>45</td>
</tr>
<tr>
<td>Scholz 1982</td>
<td>6</td>
<td>25</td>
<td>6</td>
<td>26</td>
</tr>
</tbody>
</table>

Total (95% CI)             | 278      | 220     | 100.0%     | 0.55 [0.43, 0.70]    |                        |

Total events              | 69       | 100     |            |                        |                        |

Heterogeneity: Tau² = 0.00; Chi² = 5.76, df = 6 (P = 0.45); I² = 0%

Test for overall effect: Z = 4.93 (P < 0.00001)

N=565
Mean duration 34 months

Cumulative incidence of vertebral fractures among Rochester, Minnesota, residents following the initial episode of symptomatic urolithiasis, 1950 to 1974.

Observed (solid line) and expected (dashed line)

Effect of thiazide/indapamide and K-Cit on BMD of the L2–L4 spine, femoral neck, and radial shaft of hypercalciuric kidney stone formers.

Data are expressed as percentage of normal, matched for age and gender (Z-score). **Indicates $P=0.001$, †indicates $P<0.001$. Bars above the blocks represent mean±s.d.

Hypercalciuria

- Indapamide 1.25 to 2.5 mg/day
- Chlorthalidone 25 mg/day
- HCTZ 25mg BID
- + K₃Cit (eg, Urocit®-K)
  - 15 mEq daily
Alkaline therapy

- INCREASE PH
  - Decrease supersaturation of CAOX and CAPH
  - Decrease stone growth and aggregation
Potassium

- Potassium can help make urine more basic
- bananas, potatoes, tomatoes, avocados, salmon, melon, oranges
Stone-Free Rate at 3 years

J Urol 150: 1761, 1993
Br J Urol 73: 362, 1994
J Urol 158: 2069, 1997
Changes in pH by Duration

\[ P < 0.0001 \]

Changes in Citrate by Duration

\[ P<0.01 \]

Stone Formation Rate

$P < 0.0001$

### Citrates and stone recurrence

The table below summarizes the study data on citrate and stone recurrence:

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Citrate</th>
<th>Control</th>
<th>Risk Ratio</th>
<th>Risk Ratio</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Events</td>
<td>Total</td>
<td>Events</td>
<td>Total</td>
</tr>
<tr>
<td>Soygur 2002</td>
<td>0</td>
<td>28</td>
<td>8</td>
<td>28</td>
</tr>
<tr>
<td>Ettinger 1997</td>
<td>4</td>
<td>31</td>
<td>21</td>
<td>33</td>
</tr>
<tr>
<td>Barcelo 1993</td>
<td>5</td>
<td>18</td>
<td>16</td>
<td>20</td>
</tr>
<tr>
<td>Hofbauer 1994</td>
<td>11</td>
<td>16</td>
<td>16</td>
<td>22</td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td>93</td>
<td>103</td>
<td><strong>100.0%</strong></td>
<td><strong>0.34 [0.11, 1.08]</strong></td>
</tr>
</tbody>
</table>

**Heterogeneity:** Tau² = 1.05; Chi² = 20.62, df = 3 (P = 0.0001); I² = 85%

**Test for overall effect:** Z = 1.83 (P = 0.07)

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N=479
Mean Duration 29 months

# UroRisk®

## Diagnostic Profile

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<th>Relative Supersaturation</th>
</tr>
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<tbody>
<tr>
<td>Ca</td>
<td>TV</td>
<td>CaOx</td>
</tr>
<tr>
<td>Ox</td>
<td>Na</td>
<td>Br</td>
</tr>
<tr>
<td>UA</td>
<td>P</td>
<td>NaU</td>
</tr>
<tr>
<td>Cit</td>
<td>Mg</td>
<td>UA</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Value</th>
<th>Unit</th>
<th>Value</th>
<th>Unit</th>
<th>Value</th>
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<th>Value</th>
<th>Unit</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>241</td>
<td>mg/day</td>
<td>1.59</td>
<td>l/day</td>
<td>1.90</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>mg/day</td>
<td>125</td>
<td>meq/day</td>
<td>4.53</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>253</td>
<td>mg/day</td>
<td>644</td>
<td>mg/day</td>
<td>1.07</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>58</td>
<td>mg/day</td>
<td>79</td>
<td>mg/day</td>
<td>0.21</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Other Values**

- K: 23 meq/day
- Creatinine: 777 mg/day
Topiramate / Zonegran

• Blocks Na transport channel
• Blocks Ca transport channel
• Inhibits Carbonic anhydrase II and IV
  – Distal nephron flooded with bicarbonate
  – pH increase
  – Citrate decreases
  – CaPH stones
Calcium Content

1200 mg / day

- Milk 8 oz  300 mg
- Yogurt 8 oz  350 mg
- Cheese 1 oz  200 mg
OXALATE LEVELS:
A TANGLED WEB

SPINACH: 364.44 - 1145
RHUBARB: 511 – 983.61
BEETS: 36.9 – 794.12
<table>
<thead>
<tr>
<th>Oxalate-rich foods</th>
<th>Food item</th>
<th>1 serving</th>
<th>Oxalate content (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spinach, cooked</td>
<td>½ cup</td>
<td>755</td>
</tr>
<tr>
<td></td>
<td>Rhubarb</td>
<td>½ cup</td>
<td>541</td>
</tr>
<tr>
<td></td>
<td>Almonds</td>
<td>1 oz</td>
<td>122</td>
</tr>
<tr>
<td></td>
<td>Beets</td>
<td>½ cup</td>
<td>76</td>
</tr>
</tbody>
</table>
Simplified oxalate diet

- University of Wisconsin
  - focus on spinach, nuts & seeds, and potatoes;
    - 44% of oxalate intake
    - lowest calcium:oxalate ratios….high bioavailability
    - teas, fruits and leafy green vegetables other than spinach accounted for <10% of total oxalate consumed
      - (Abstract 2060)
CHOCOLATE

Calcium and Oxalate

<table>
<thead>
<tr>
<th></th>
<th>DARK</th>
<th>MILK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxalate (mg)</td>
<td>94</td>
<td>94</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>26</td>
<td>430</td>
</tr>
</tbody>
</table>
Vitamin B-6

- ↑ oxalate excretion with B-6 deficient diet
- ↓ stone risk with ↑ B-6 intake
- Co-factor in AGT conversion of glyoxylate to glycine
Hyperoxaluria: Vitamin B6

- bananas, avocados, soybeans, halibut, mangos, oatmeal
  - fortified ready-to-eat cereals, select breads

Supplements:
50mg ....100mg.....200mg
Average Daily Oxalate Excretion

- Pre-intervention (SD 30.25)
- Post-intervention (SD 14.1)

57 pts
15 month follow-up
72% of pts responded

P<0.0001
Calcium Oxalate Supersaturation

P<0.001

72% of pts responded

57 pts
15 month follow-up
Gastric Bypass

Pre-Op to 1 year: $P = 0.00002$
Low Citrate Levels

Citrate Levels below 320 mg/day
URIC ACID STONES

- 15%
- Radiolucent on KUB
- Hounsfield units <320
- Urine pH <5.5
- Gout
- DISSOLVE – Alkalinize
- PREVENT – Alkalinize and Allopurinol
Sources of Uric Acid

• End product of purine metabolism
  – Endogenous
    • de novo synthesis / catabolism of nucleic acid
    • 300-400 mg/day
  – Exogenous
    • dependent on dietary intake
    • Average 200-300 mg/day
High animal protein diet

- Increases urinary calcium, uric acid
- Decrease citrate and urinary pH
- Increase bone resorption due to increased acid-ash content

Br J Urol 56: 263, 1984
Am J Kid Dis 40: 265, 2002
PROTEIN

- Not a low protein recommendation but rather adequate protein
- 0.8-1.0 grams/kilogram
- Plant protein less likely to make urine acidic
- high fructose corn syrup
  • associated with hyperuricemia and hyperuricosuria

Am J Clin Nutr 49: 832, 1989
Changing trends in American diet over the past 38 years correlating to the increased prevalence of kidney stones
S De, X. Liu, M. Monga

- Objective: To compare the reported increasing stone prevalence$^{1,2}$ to corresponding changes in the USDA Food Distribution database
pH Dependence of Uric Acid Solubility

- Solubility of Uric Acid ($pK_a = 5.57$)
  - pH 5.0  60 mg per L
  - pH 6.0  200 mg per L
  - pH 7.0  1600 mg per L

K-Cit 15 mEq qD and titrate up if needed pH 6.5
CHEMISTRY OF URIC ACID

From Maalouf et al. Curr Opin Nephrol Hypertens, 2004
Allopurinol

• End product of purine metabolism
  – Endogenous
    • xanthine → uric acid
      xanthine oxidase

Allopurinol if:
• fails to correct with dietary measures
• Urinary uric acid >900 mg/day
• Start at 100mg and titrate to 300mg if needed
NO RCTs evaluating impact on stone recurrence

- Uric acid stones
  - Allopurinol
  - Alkalinization
Responders to Diet

![Graph showing the percentage of patients with various conditions after 10 months of follow-up. The conditions are Low Volume, Hypernatriuria, Hypocitraturia, Hypercalciuria, Hyperuricosuria, and Hyperoxaluria. 137 pts were followed up for 10 months.]
Percentage of patients responding to Medical Therapy

127 pts
Average follow up 14.39±17.36 months
IMPORTANCE OF FOLLOW-UP

• Urine
  – Repeat single 24-hr urine collection at ≤3 mo to assess response to treatment and then according to severity of disease
  – Periodic urine culture in pts w/ infection stones

• Blood
  – Periodic testing to identify adverse effects

Courtesy Peggy Pearle - UTSW
IMPORTANCE OF FOLLOW-UP

• Urine
  – Repeat single 24-hr urine collection at ≤6 mo to assess response to treatment and then according to severity of disease
  – Periodic urine culture in pts w/ infection stones

• Blood
  – Periodic testing to identify adverse effects
    • thiazides

K+, glucose, uric acid, Ca, Cr

Courtesy Peggy Pearle - UTSW
IMPORTANCE OF FOLLOW-UP

• Urine
  – Repeat single 24-hr urine collection at $\leq 6$ mo to assess response to treatment and then according to severity of disease
  – Periodic urine culture in pts w/ infection stones

• Blood
  – Periodic testing to identify adverse effects
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    • potassium citrate

Courtesy Peggy Pearle - UTSW
IMPORTANCE OF FOLLOW-UP

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Courtesy Peggy Pearle - UTSW
IMPORTANCE OF FOLLOW-UP

• Urine
  – Repeat single 24-hr urine collection at ≤6 mo to assess response to treatment and then according to severity of disease
  – Periodic urine culture in pts w/ infection stones

• Blood
  – Periodic testing to identify adverse effects
    • thiazides
    • potassium citrate
    • allopurinol
    • tiopronin

CBC, BMP, LFTs, Ur prot/cr ratio

Courtesy Peggy Pearle - UTSW
CYSTINE STONES

DIETARY TREATMENT

Fluid Intake
- Goal urine volume 3 L/day in adults and 40 to 50 mL/kg/day for children
- Citrus drinks increase alkali and pH

Animal protein
- Source of methionine, precursor to cystine

Sodium
- Sodium ↑ cystine excretion

Courtesy Michael Lipkin - Duke
CYSTINURIA

Management

Alkalization

Urocit®-K 15 mEq BID
- pKa = 8.3
- risk Calcium Phosphate calculi when pH > 7-7.5

Important: optimizes effectiveness of Thiola
Cystine = two cysteine molecules with disulfide bridge
Cystinuria: Cystine-binding drugs

- Penicillamine: One 250 mg tab decreases urine cystine about 75-100 mg per day
  - Usual dose 0.5-2 g per day: 75% benefit*
  - Many side-effects (fever, arthralgia, leukopenia, nephropathy)
- Tiopronin 400-1200 mg per day
  - 70% benefit: Fewer side-effects.*
- Captopril 75-150 mg/d can reduce urine cystine concentration by as much as 50%
  - Low BP major side-effect

Dietary sodium restriction important since increase sodium excretion promotes increase cystine excretion
Cystine Stones

Treatment

• If urinary cystine concentration is >500 mg/L
  – Start Tiopronin (eg, Thiola®) at 200 mg bid
  – Adjust dose to keep cystine concentration <200 mg/L of urine
Infection Stones

- Struvite
- Magnesium Ammonium Phosphate
- pH > 7.0
- Urease producing organisms
  - Pseudomonas
  - Klebsiella
  - Proteus
  - Staph
  - Mycoplasma, ureaplasma
- Rare E. Coli
Risk factors for Renal Deterioration after PCNL for Staghorns

- 8 year f/u – 28% renal deterioration
  - Solitary kidneys 77%
  - Recurrent stones 39%
  - Hypertension 50%
  - Complete staghorns 34%
  - Urinary diversion 58%
  - NGB 47%
  - Refused surgery 100%

J UROL 153: 1403-7, 1995
Risk factors for Renal-related DEATH from Staghorns

- 8 year f/u
  - Stone-free 0%
  - Residual fragments 3%
  - Refused surgery 67%

J UROL 153: 1403-7, 1995
Medical Therapy - Struvite

• AHA
  – Acetohydroxamic acid 250 TID
    • Contraindicated CR>2.5
    • Anemia, thrombocytopenia, thromboembolic events
  – RCT
    • Primarily SCI
    • Significant reduction in growth of residual stone
    • No documented impact on stone recurrence

– Suppressive antibiotics
  • Never studied
EXERCISE AND STONES

- National Health and Nutrition Examination Survey database from 2010-2011
  ‘Have you ever had a kidney stone.’ 8.3% YES

Q1: *moderate intensity sports* for at least 10 minutes continuously?
Q2: *vigorous intensity sports* for at least 10 minutes continuously
Q3: *For the usual way you travel do you walk / bicycle for at least 10 minutes*
Q4: *Does your work involve vigorous-intensity activity for at least 10 minutes continuously.*

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>RR</th>
<th>Univariate</th>
<th>Multivariate</th>
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