Renal Stones:

Rotaru Dumitru, MD

Overview

- Introduction
- Contribution to CKD/ESRD
- Pathophysiology
- Diagnosis/Acute Management

- Types of stones diseases
- Appropriate Workup
- Dietary & Medical Management
Burden of Nephrolithiasis

- 450,000 ED visits for Acute Renal Colic
- 1 in every 100 hospital admissions
- 2 Million outpatient visits
- 5 Billion in medical cost and lost income
- 12% of Men and 5% of Women have a symptomatic stone by age of 70.
- 50% of stone formers have recurrent stones.
- Increased Risk of CKD

Stone Disease and CKD

- Risk of Renal Injury:
  - Female sex (m)
  - Pediatric age (i)
  - Struvite lithiasis (M)
  - Unsuccessful removal of struvite stones (M)
  - Favorable conditions for UTI (i)
    - Urinary indwelling catheter
    - Neurogenic bladder
    - Vesicoureteral reflux
    - Prostate hypertrophy
- Underlying pathology
- Stone Composition
- Type and number of urological interventions

**Stone Disease and CKD:**

**Potential Mechanisms**

- Prolonged obstruction => renal atrophy
- Intermittent obstruction
  - Chemoattractants => Macrophage Infiltration => Fibrosis
- Oxalate: generation of free radicals
- Nephrocalcinosis
- Infection: papillary necrosis, toxic ammonium ions
- Stone Extraction Procedures
  - Direct renal injury


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**Stone Disease and CKD**

- Olmsted County, MN, Database
- 4774 stone formers compared to 12,975 controls
  - stone formers are:
    - More likely to be diagnosed as CKD (GFR<60)
      20% vs. 13% = HR of 1.67 (1.48 to 1.88)
    - At baseline stone formers more likely to have:
      - Gout, DM, obesity, dyslipidemia, CAD

Stone Disease and ESRD

- Necker France from 1989 to 2001
  - 1,391 incident dialysis patients: 45 pts had stones as primary cause of ESRD (3.2%) or 3.1/mil/yr
    - Struvite 42%
    - Calcium 26.7%
    - Uric acid 17.8%
    - Hereditary 13.3%
  - USRDS 2.9 cases per million pop/yr.
  - ESRD in patients with - delayed diagnosis, suboptimal surgery/medical tx, and severe stone disease


Pathogenesis

- **Crystaluria**: 15-20% of healthy subjects
  - If urine is supersaturated with a stone forming salt
    - => **Nucleation** (crystal aggregation)
    - => **Anchoring** (cells, Randall plaques)
    - => Stone formation
  - Crystal formation inhibitors

Pathogenesis

- Randall’s Plaques:
  - Intraoperative biopsies during stone removal
  - Calcium phosphate deposits (apatite) in renal papillae
  - Originate from the loop of Henle and extend in the renal interstitium

- Biopsies from:
  - Idiopathic hypercalciuric stone formers
  - Bariatric surgery related stone formers (hyperoxaluric)
  - Brushite stone formers (Calcium phosphate)
  - Cystine stone formers


Stones attached to plaques in CaOx stone formers

Pathogenesis: Randall’s Plaque

No Plaques. Stones arising from IMCD

CaP in ducts of Bellini and extruding from papilla as plaque

Brushite

Brushite

Bariatric Surgery

Plaques with yellow stone

Plaques with white cystine stone


Presentation of Stone Disease

- **Renal Colic** – paroxysms of pain lasting 20-60 min
- Site of obstruction dictates location of pain
  - Upper ureter – flank pain
  - Lower ureter – ipsilateral groin pain
  - UVJ – mimics cystitis
  - Can present as “acute abdomen”
- **Hematuria**
  - usually at onset of pain, clots
- **Nausea & Vomiting**
- UTI, AKI, incidental finding
**Diagnosis**

- Non-Contrast CT scan = Gold Standard
  - May detect alternate pathology as well (i.e. appendicitis)
  - Will detect “radiolucent stones”
- Ultrasound – if cannot have radiation
- IVP – no longer preferred procedure
  - Contrast, time, low sensitivity
- MRI – really only in pregnant women
- Plain film – f/u exams

**Acute Management**

**PAIN**

NSAIDS or OPIATES
- Ketorolac 60 mg IV vs. Meperidine 50 mg IV
- NSAIDs: decreasing smooth muscle tone
- Similar potency
- Combination is better

**MEDICAL EXPULSION**

- Alpha Blocker
  - Better than no meds
- Calcium Channel Blocker
  - Comparable to Alpha blocker
- Most frequently:
  - Tamsulosin and Nifedipine

*Ann Emer Med* 1996;24:359
BMJ 2004;328:410
| J Urol 2007;177:985 |
| J Urol 2004;172:316 |
Seeking Expert Help

- Urology Consult for stone >10 mm, renal failure, urosepsis, unrelieved pain, failure to pass stone <10 mm
- Infection and obstruction is a medical emergency
- Likelihood of passage depends on stone size/location
  - 1 mm = 87%
  - 2-4 mm = 76%
  - 5-7 mm = 60%
  - 7-9 mm = 48%
  - >9 mm = 25%
- Renal or Urology consult for stone workup, especially for recurrent stones

Am J Roentgenol 2002;178:101

Types of Stones

- Mixed Calcium
- Calcium Oxalate
- Calcium Phosphate
- Uric Acid
- Struvite
- Cystine
- Drug Related
Calcium Stones: Crystalluria

CaOx Dihydrate

CaOx Monohydrate

Pictures from Up To Date

Calcium Stones

- 80-90% of all stones
- Mixed calcium > calcium oxalate > calcium phosphate

Common risk factors
- Low urine volume
- Hypercalciuria
- Hypocitraturia

Individual risk factors
- Hyperoxaluria = CaOx
- High Urine pH = CaP precipitates in pH > 6.5
- Congenital abnormalities of urinary tract
- Medications

Hypercalciuria

- Defined as Ca excretion (>4mg/kg/day)
  - Women >250 mg/day
  - Men >300 mg/day

- Mechanisms:
  - Increased filtered load of Ca
    - Overwhelms resorptive capacity of kidney
  - Decreased proximal reabsorption
    - Ca^{2+} reabsorption parallels Na^{+} reabsorption
  - Decreased distal reabsorption
    - Suppressed PTH, acidosis, phosphate depletion

Hypercalciuria

<table>
<thead>
<tr>
<th>Idiopathic (90%)</th>
<th>Secondary</th>
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<tbody>
<tr>
<td>• Phenotype = Low PTH, high Calcitriol, low bone density</td>
<td>• Milk-alkali</td>
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<tr>
<td>• Mechanisms: ↑Intestinal absorption</td>
<td>• Vitamin D intoxication</td>
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<td>↓Renal Ca/Phos reabsorption</td>
<td>• Sarcoid</td>
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<tr>
<td>↑Bone demineralization</td>
<td>• Primary</td>
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<td>• Complex genetic dz?</td>
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<td>• Immobilization</td>
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<td>• Paget’s</td>
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<td></td>
<td>• Hyperthyroidism</td>
</tr>
<tr>
<td></td>
<td>• RTA</td>
</tr>
</tbody>
</table>
Hypercalciuria

- Can Be Genetic
  - Dent’s Disease: X-linked recessive
    - Defect in CLC-5 = Chloride-proton antiporter
    - Proximal tubule defect resulting in:
      - Hypercalciuria, nephrocalcinosis, stones, renal failure, low molecular weight proteinuria

Hypercalciuria

Treatment:

- Urine alkalization
  - Kcitrate: 60-80 meq/day, titrate to pH of 6.5

- Thiazides:
  - increases urinary Ca resorbtion
  - if patient has systemic alkalosis
  - if urine alkalization is not effective
  - must prevent hypokalemia (reduces citrate)
Hyperoxaluria

- Defined as oxalate excretion:
  - Women > 45 mg/day
  - Man > 55 mg/day

- Oxalate Sources:
  - Endogenous (90%): liver from glycine
  - Dietary: oxalate and ascorbic acid

Hyperoxaluria

- Ca++ binds oxalate in gut => prevents absorption

- Increased intestinal absorption:
  - High oxalate diet, Low Calcium Diet
  - Increased intestinal Ca++ absorption
  - Malabsorption: gastric bypass, inflammatory bowel, cystic fibrosis, chronic pancreatitis

- Alterations in GI flora: Oxalobacter formigenes

- Enzyme deficiency: Primary Hyperoxaluria
Hyperoxaluria

Treatment:

- Low oxalate diet
- Low fat diet: increases Ca++ available to bind oxalate
- Tums (Calcium)
- Cholestyramine

<table>
<thead>
<tr>
<th>Oxalate Rich Foods</th>
<th>Dietary Content (mg)</th>
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<tbody>
<tr>
<td>Beet greens, cooked</td>
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<tr>
<td>Potatoes, frozen, Blink</td>
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</tr>
<tr>
<td>Rhubarb, uncooked, no sugar</td>
<td>13 mg</td>
</tr>
<tr>
<td>Spinach, ice cream</td>
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<tr>
<td>Oranges, refinery</td>
<td>13 mg</td>
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<tr>
<td>Canned, frozen, apricot</td>
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<tr>
<td>Rhubarb, frozen</td>
<td>12 mg</td>
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<tr>
<td>Spinach, leaves</td>
<td>12 mg</td>
</tr>
<tr>
<td>Spinach, uncooked</td>
<td>12 mg</td>
</tr>
<tr>
<td>Oranges, uncooked</td>
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<td>Oranges, cooked</td>
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Hypocitraturia

- Defined as citrate excretion
  - <350 mg/day in men
  - <500 mg/day in women
- Citrate = inhibitor of crystal formation
  - Forms nondissociable, soluble complex with Ca++
  - Prevents nucleation (growth) of CaOx
- Causes:
  - Excessive protein intake, metabolic acidosis, starvation
  - Hypokalemia, hypomagnesemia, Acetazolamide
Hypocitraturia

Treatment:

- Potassium Citrate or Potassium-magnesium citrate
  - <150 mg/24 hr citrate – 60 meq daily
  - >150 mg/24 hr citrate – 30 meq daily
- Mechanisms: increase in K+ and Citrate
- Hypokalemia -> increased citrate reabsorption

Hyperuricosuria

- Defined as Uric Acid excretion
  - >800 mg/day in men
  - >750 mg/day in women
- Decrease CaOx solubility: binding inhibitors
- Nidus for CaOx stone formation
- Curhan and Taylor: 24 hr uric acid did not predict calcium stone formation
- Treatment:
  - Empiric Allopurinol reduced CaOx stone recurrence
  - High urine volume, decrease protein intake
**Medullary Sponge Kidney**

Parallel striations of contrast material extending from surface of papilla.

Demonstrate irregular enlargement of medullary and inner papillary collecting ducts.

Represents 12% of Ca Stone formers.

Predisposed to nephrocalcinosis.

Often present with stones, recurrent UTI.

Associated with RTA.

Kawashima A et al. Radiographics 2004;24:S35-S54

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**Other Calcium Stone Risk Factors**

- Low Urinary Volume: perhaps most obvious

- Obesity: as body size increases, oxalate and uric acid excretion increase

- Dietary Factors
  - High Na⁺, animal protein, sucrose, fructose, Vitamin C, and Ca++ supplements
Uric Acid Stones

- 5-10% in Western World
- 30-40% in hot, arid climates
- Uric Acid = end-product of purine metabolism
- Insoluble at low pH

Uric Acid Stones: Risk Factors

- Low Urine Volume
  - Hot, Arid climate
  - Diarrhea, insensible losses
- Low Urine pH (<5.5)
  - High animal protein diet
  - Diarrhea, Insulin resistance
- High Urinary Uric Acid (UA)
  - >800 mg/day in Men
  - >750 mg/day in Women
  - Mechanisms
    - Dietary Excess
    - Drugs: probenecid
    - Overproduction
### Uric Acid Overproduction

**Inherited enzyme defects** leading to purine overproduction:
- Hypoxanthine-guanine phosphoribosyltransferase deficiency
- Phosphoribosylpyrophosphate synthetase overactivity
- Glucose-6-phosphatase deficiency (glycogen storage disease, type 1)

**Clinical disorders leading to purine and/or urate overproduction**:
- Myeloproliferative disorders
- Lymphoproliferative disorders
- Malignancies
- Hemolytic disorders
- Psoriasis
- Obesity
- Tissue hypoxia
- Down syndrome
- Glycogen storage diseases (types III, V, VII)

**Drug-, diet-, or toxin-induced purine and/or urate overproduction**:
- Ethanol
- Excessive dietary purine ingestion
- Pancreatic extract
- Fructose
- Vitamin B12 deficiency
- Nicotinic acid
- Ethylamino-1,3,4-thiadiazole
- 4-amino-5-imidazole carboxamide riboside
- Cytotonic drugs
- Warfarin

Adapted from utdol.com

### Uric Acid Stones

**Diagnosis**
- Radiolucent on plain radiographs
- Detectable on US and CT
- Stone analysis (definitive)

**Treatment**
- Maintain UOP >2L/day, low purine/protein diet
- Alkali = potassium citrate or bicarbonate
  - Start at 30 meq BID – titrate to pH 6.5 but no more
  - Acetazolamide 250 mg QHS – added if am void is acidic
- Allopurinol: if recurrence or >1000 mg/day of uric acid
Struvite-Carbonate Stones = Infection Stones

- Coffin-lid crystals
  - Struvite = magnesium ammonium phosphate
- 5-15% of all stones
- Urea-Splitting organisms
  - Proteus
  - Morganella
  - Providencia
  - Klebsiella

Struvite Stones: Pathogenesis

- Ammonium, Carbonate, Low urinary pH
  - Urea $\xrightarrow{\text{Urease}} 2\text{NH}_3 + \text{CO}_2$, $\text{NH}_3 + \text{H}_2\text{O} \rightarrow \text{NH}_4^+ + \text{OH}^-$
  - $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{carbonic acid} \rightarrow \text{bicarbonate}$
  - Bicarbonate = increase pH $>7 = \text{CaP precipitation}$

- Other stones that gets secondarily infected.

- 75% of staghorns are struvite

www.uhrad.com/ctarc/ct191.htm
Struvite Stones

- **Risk Factors:**
  - Women, spinal cord trauma, neurogenic bladder, ileal diversion of ureter, catheters.

- **Diagnosis:**
  - Most seen on KUB but less radiopaque than calcium
  - Stone analysis and culture
  - If stone culture negative = think of ureaplasma

- **Treatment:**
  - Nephrolithotomy and ESWL
  - Chronic-suppressive antibiotics
  - Urease Inhibitors (Acetohydroxamic acid); Chemolysis
  - Up to 30% recurrence rate: nephrectomy in failures

Cystine Stones

- 1% of adult, 5-8% in children stones
- Autosomal recessive or dominant with incomplete penetrance
- Defect in reabsorption of dibasic amino acids: ornithine, arginine, lysine, cysteine
- Cystine = dimer of cysteine
  - COOH-CHNH2-CH2-SH
  - Much less soluble

www.thekidneystones.com
Cystine Stones: Pathophysiology and Diagnosis

- Solubility of Cystine is pH dependent
  - pKa of Cystine is 6.5
  - Solubility = 243mg/L

- Diagnosis
  - Hexagonal crystals
  - Radio opaque: high sulfur content
  - Quantitative test:
    - Normal ~30 mg/day
    - Cystinuric patients >400 mg/day

Cystine Stones: Treatment

Goal = [cystine] below solubility level = 243mg/L

- Adjust Urine Output
  - 750 mg/day of cystine / 250 mg/L = 3L/day of Urine

- Alkalization
  - Target is urine pH to 7.0
  - Potassium citrate = 3-4 meq/kg/day
  - Acetazolamide QHS if am urine has low pH

- Na+ restriction 50-100 meq/day
- Protein restriction to 0.8 – 1 g/kg/day due to Methionine
Cystine Stones: Treatment

- Cystine-binding drugs
  - Competitively bind cysteine to form more soluble cx
  - **Penicillamine:**
    - 250 mg tablet reduces urine cystine by 75-100 mg/day
    - Many side effects = fever, rash, leukopenia
  - **Tiopronin:**
    - Usual dose is 400-1200 mg/day
  - **Captopril:**
    - 75-150 mg/day can decrease cystine by 50%
    - Efficacy is unproven
- Monitor every 3-6 months until stable

Drug-related Stones

- Acyclovir or Methotrexate crystal induced AKI
- Sulfonamide Abx – insoluble in pH <5.5
- Ethylene glycol – metabolized to oxalate in urine
- Vitamin C – increases oxalate absorption/precursor
- Indinavir
  - protease inhibitor
  - radiolucent stones
Renal Stones: Evaluation

- **Basic evaluation**
  - All patients with a single stone, 50% recurrence

- **Complete evaluation**
  - Controversial for a single kidney stone: cost-benefit ratio
  - 24 hour urine collections with a typical diet

- **Study of Urology visits for recurrent stones**
  - 92% had a procedure
  - 56% of charts documented intention to evaluate
  - 35% actually had a complete evaluation

Renal Stones: Evaluation

- **Who should have complete evaluation**
  - **Complicated disease**
    - Multiple stones
    - New stone formation or enlargement of old stones
    - Passage of gravel
  - **Special Groups**
    - White males – 60% lifetime recurrence
    - Blacks – stones are less common
    - Chronic diarrhea, bowel surgery
    - UTI, Gout, osteoporosis or fractures
    - Obese, diabetes, family history
    - Cystine, Uric Acid, CaP, Struvite stones
    - Transplant, occupational safety.
Limited Evaluation: After 1st Stone

- **Focused History**
  - Dietary – high protein/salt/oxalate/Vit C, low fluid and calcium intake, excessive Vit D or sugar
  - Family/Personal – stone dz, IBD, skeletal dz

- **Image studies**: stone burden, Xray/CT

- **Stone Analysis**

- **UA with microscopy +/- culture**

- **Urinary Sediment** – for crystals

- **BMP, Ca, Phos, Uric Acid**

Interpreting Labs

- High Calcium – suggests HPTH
- Creatinine – diagnose CKD
- Low Bicarb – suggests RTA or diarrhea
- Low K – suggests RTA, eating disorders, GI disease
- Uric Acid – detect hyperuricemia
**Interpreting UA**

![Diagram showing pH with branches for >6.5 and <5.5, leading to RTA, Uric Acid, Infection, CaOx, and CaOx]

**Stone Analysis**

- Stone type => certain metabolic diagnosis
  - Calcium phosphate – RTA, 1° hyperparathyroidism
  - Uric Acid – Gouty diathesis, chronic diarrhea
  - Struvite – infection
  - Cystine – cystinuria

- Calcium Oxalate Stones
  - Do not suggest a certain diagnosis.

Emperic Treatment

• Increase Fluid Intake
  • 199 patients assigned to a UOP to 2 L/day vs. no therapy
  • At 5 years recurrent stone 12% vs. 27%
  • Average increase in UOP of 300 ml/day

• Decrease intake:
  - oxalate, Na+, sucrose, fructose, protein

• Liberal calcium diet, but no supplements

Dietary Advice

• Is the Internet a reliable source?  NOT ALWAYS
  • Google search study of 460 sites
  • Fluid/calcium/salt/protein advice
  • 365 deficient, 80 correct, 10 inaccurate

• Avoid Low Calcium Diet!
  • Reason = calcium prevents oxalate absorption
  • Borghi et al. 30mmol/day vs. 10mmol/day Ca
  • 0.49 = relative risk of recurrence in higher Ca group

References:

J Endourol. 2009 Apr;23(4):795-7
N Engl J Med 2002;346:77-84
**Dietary Advice**

- Reduce Soft Drink intake
  - No sodas vs. current habits
  - 6.4% reduction overall, 15% reduction if drank dark soda

- Do not always need to drink water
  - ½ cup Real Lemon in 7 ½ cups of water, sweetened to taste
    - 6meq/L of citrate
  - Diet Mt. Dew, Diet Orange Crush, Fresca, Sprite Zero all have similar levels of citrate
  - Orange Juice, Pineapple Juice, Crystal light lemonade – if drink 2, 8oz. glasses daily = 60 meq citrate

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**Dietary Advice**

- Tea/Coffee: likely no increased risk.
  - Some concern over oxalate in “black teas”
- Orange Juice: no risk or perhaps some benefit.
  - Very high Potassium, but also sugar
- Cranberry Juice: no studies to prove beneficial
- Grapefruit Juice: not recommended despite being high in citrate
  - Inhibits Cytochrome P450 enzymes
Complete Evaluation

- Limited Evaluation Plus...
- PTH – if screening Ca++ elevated (>10)
- IVP? – to eval for possible medullary sponge kidney
- Cystine Screening
- Two 24 hour urine collections
  - Calcium, Oxalate, Citrate, Uric Acid, Sodium, Phosphate, Potassium, Magnesium
  - pH
  - Volume
  - Creatinine
  - Repeat 6-8 weeks after treatment and then yearly


24-hour Urine

- 2 collections: normal diet
- More collections = more lithogenic factors found
- 6-8 weeks after obstruction or extraction procedure, repeat yearly
- Target treatment based on urine values

Normal Values for 24-hr Urine

<table>
<thead>
<tr>
<th>Substance</th>
<th>Man</th>
<th>Woman</th>
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<tbody>
<tr>
<td>Calcium</td>
<td>&lt;300</td>
<td>&lt;250</td>
</tr>
<tr>
<td>Uric Acid</td>
<td>&lt;800</td>
<td>&lt;750</td>
</tr>
<tr>
<td>Citrate</td>
<td>&gt;350</td>
<td>&gt;500</td>
</tr>
<tr>
<td>Oxalate</td>
<td>&lt;55</td>
<td>&lt;45</td>
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</table>
24-hr Urines

- No absolute safe cutoff point for lithogenic factors
- Can still form stones with normal values
- Urinary supersaturation more important
- Treat to 70% below/above normal as an initial goal
  - (i.e. if calcium is 300, treat to 210)
- Risk appears to be more linear
  - (i.e. as Calcium increases within normal values stone risk increases)

### Nurses Health Study Cohort I

<table>
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<tr>
<th>Calcium, mg</th>
<th>Cases</th>
<th>Controls</th>
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<td>100–149</td>
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<td>1.26 (0.84–1.91)</td>
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<tr>
<td>150–199</td>
<td>165</td>
<td>85</td>
<td>1.52 (0.99–2.34)</td>
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<td>200–249</td>
<td>154</td>
<td>68</td>
<td>1.84 (1.17–2.90)</td>
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<tr>
<td>250–299</td>
<td>96</td>
<td>43</td>
<td>1.93 (1.15–3.24)</td>
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<tr>
<td>300–349</td>
<td>73</td>
<td>25</td>
<td>2.68 (1.46–4.93)</td>
</tr>
<tr>
<td>350+</td>
<td>83</td>
<td>21</td>
<td>4.94 (2.53–9.67)</td>
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</table>

<table>
<thead>
<tr>
<th>Oxalate, mg</th>
<th>Cases</th>
<th>Controls</th>
<th>RR</th>
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<tr>
<td>&lt;20</td>
<td>100</td>
<td>63</td>
<td>1.00 (Ref.)</td>
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<tr>
<td>20–24</td>
<td>171</td>
<td>105</td>
<td>1.15 (0.75–1.77)</td>
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<tr>
<td>25–29</td>
<td>224</td>
<td>99</td>
<td>1.59 (1.03–2.46)</td>
</tr>
<tr>
<td>30–39</td>
<td>278</td>
<td>93</td>
<td>2.51 (1.59–3.96)</td>
</tr>
<tr>
<td>40+</td>
<td>125</td>
<td>43</td>
<td>2.36 (1.35–4.13)</td>
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</table>

P, trend <0.001

### Nurses Health Study Cohort I

<table>
<thead>
<tr>
<th>Citrate, mg</th>
<th>Cases</th>
<th>Controls</th>
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<tr>
<td>&lt;200</td>
<td>146</td>
<td>35</td>
<td>1.00 (Ref.)</td>
</tr>
<tr>
<td>300–399</td>
<td>91</td>
<td>30</td>
<td>0.72 (0.40–1.28)</td>
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<tr>
<td>400–499</td>
<td>110</td>
<td>46</td>
<td>0.63 (0.37–1.08)</td>
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<tr>
<td>500–599</td>
<td>121</td>
<td>61</td>
<td>0.50 (0.30–0.83)</td>
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<tr>
<td>600–699</td>
<td>106</td>
<td>48</td>
<td>0.56 (0.33–0.96)</td>
</tr>
<tr>
<td>700–799</td>
<td>105</td>
<td>47</td>
<td>0.54 (0.31–0.94)</td>
</tr>
<tr>
<td>800+</td>
<td>219</td>
<td>136</td>
<td>0.33 (0.20–0.55)</td>
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</table>

P, trend <0.001

### Nurses Health Study Cohort I

<table>
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<th>Uric acid, mg</th>
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<th>RR</th>
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<tr>
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<td>353</td>
<td>161</td>
<td>1.00 (Ref.)</td>
</tr>
<tr>
<td>200–499</td>
<td>248</td>
<td>116</td>
<td>0.96 (0.69–1.33)</td>
</tr>
<tr>
<td>500–599</td>
<td>159</td>
<td>59</td>
<td>1.07 (0.70–1.64)</td>
</tr>
<tr>
<td>600–699</td>
<td>69</td>
<td>40</td>
<td>0.64 (0.37–1.09)</td>
</tr>
<tr>
<td>700–799</td>
<td>39</td>
<td>16</td>
<td>0.85 (0.40–1.82)</td>
</tr>
<tr>
<td>800+</td>
<td>30</td>
<td>11</td>
<td>0.72 (0.29–1.80)</td>
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</tbody>
</table>

P, trend 0.30

GC Curhan, EN Taylor. 24-hr uric acid excretion and the risk of kidney stones. AJKD 73, 489–496.
Dietary Treatment of Idiopathic Ca Stones: Based on Metabolic Workup

- Specific Diet (113) vs. General “stone clinic” advice (94)
  - Hypercalciuria – restrict animal protein, 1gm calcium
  - Hyperuricosuria – 80gm/day meat, 1-2 meatless days/wk
  - Mild Hyperoxaluria – increase dairy, lemons and fiber, restrict oxalate
  - Hypocitraturia – restrict animal proteins, 1-2 lemons/day or orange juice, increase fruits/vegetables
- 6% vs. 19% recurrent stones (P<0.01)

BJU International (1999). 84. 393-398

Nephrolithiasis: Summary

- Can result in CKD/ESRD
- Should be evaluated appropriately
- Treatment based on stone composition metabolic evaluation and dietary history
- Should be monitored periodically