Kidney Stone Management

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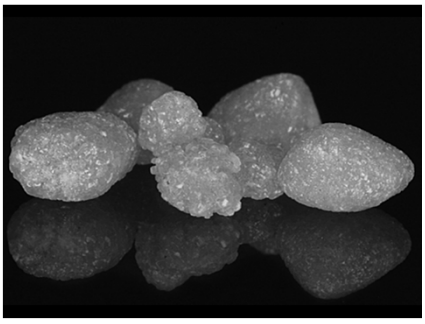
Disclosures

- **Consultant – Boston Scientific**
- **Consultant - ThermDX**
- **Course Instructor – Coloplast**

Introduction

- Prevalence and Cost
- Overview of diagnostic imaging
- Surgical options



Prevalence

- Prevalence in the U.S. – 8.8%
  - Male – 10.6%
  - Female – 7.1%
  - Obese – 11.2%
  - Normal wt – 6.1%
- Both obesity and diabetes strongly associated with stone disease
- Marked increase from 1 in 20 in 1994

Scales et al, Eur Urol, Jul, 2012

1 out of every 11 American will experience a kidney stone during their lifetime

Costs

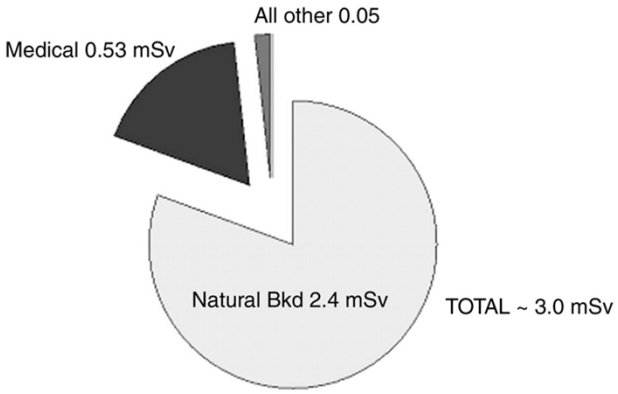
- **In 2000:**
  - **Evaluation/treatment of stones > $2.07 billion in the U.S.**
  - **Inpatient stays - 177,496 adults with stones as primary diagnosis**
  - **Outpatient – ≈ 2,700,000 visits for "urolithiasis"**

Source: NIDDK: National Kidney and Urologic Diseases Information Clearinghouse

Imaging in Stone Disease

Increase in Radiation Exposure

1980

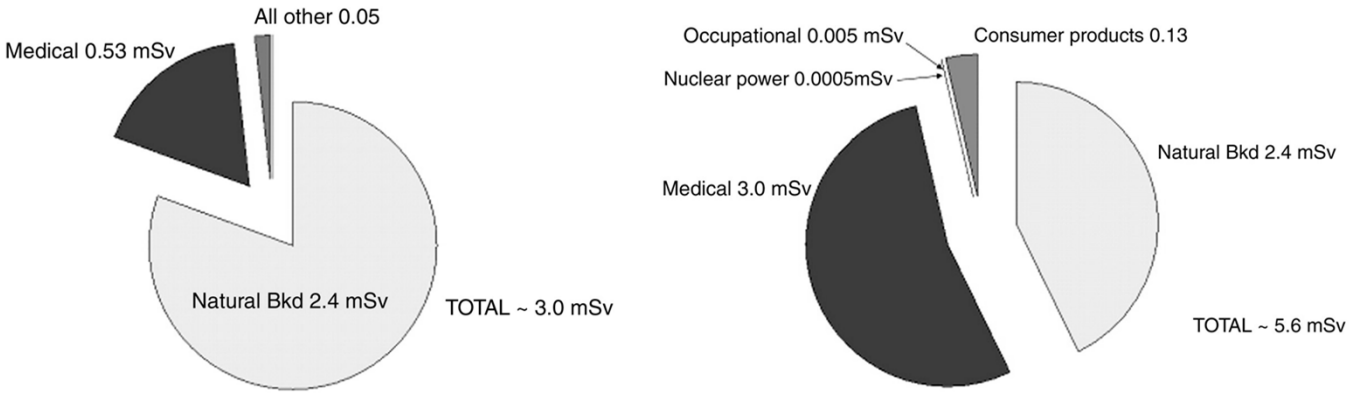


Figures 1a, 1b
Mettler F A, Bhargavan M, Faulkner K, et al. Radiologic and nuclear medicine studies in the United States and worldwide: Frequency, radiation dose, and comparison with other radiation sources—1950-2007. *Radiology* 2009;253:520-531.

Increase in Radiation Exposure

1980

2006



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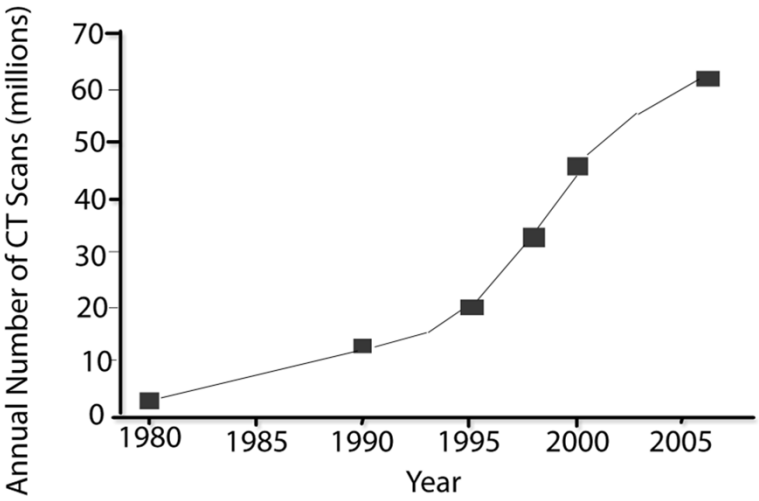
Increase in CT Imaging



N Engl J Med 2007; 357:2277-2284

ALARA

- **ALARA is an acronym for As Low As Reasonably Achievable. This is a radiation safety principle for minimizing radiation doses and releases of radioactive materials by employing all reasonable methods. ALARA is not only a sound safety principle, but is a regulatory requirement for all radiation safety programs.**

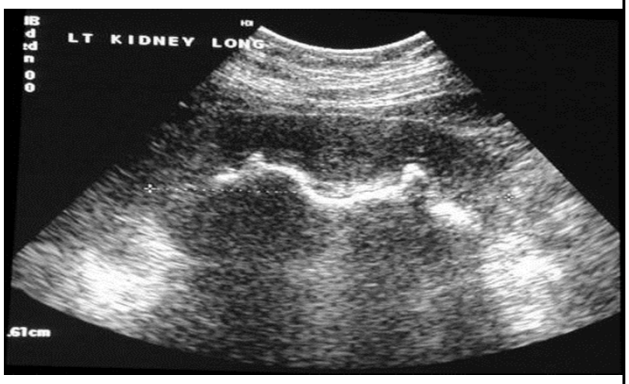
Radiation Safety and ALARA
https://www.ncsu.edu/ehs/radiation/forms/alara.pdf

Pre-operative Imaging: Plain Abdominal Radiograph (KUB)

- KUB
  - Sensitivity - 58 – 62%
  - Specificity - 67 – 69%
  - Calcium containing stones most easily visualized, especially dense CaOx monohydrate and CaP brushite
  - Pure uric acid – radiolucent
  - Inexpensive

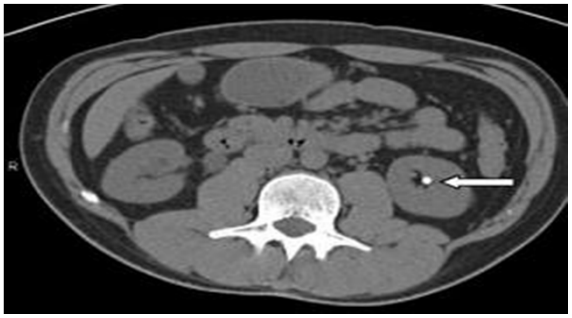
Pre-operative Imaging: Renal Ultrasound

- Renal ultrasound
- Sensitivity ≈ 60%
- Sensitivity and specificity are operator and patient body habitus dependent
- Large stones in the kidney and hydronephrosis readily appreciated
- Small stones, ureteral stones, and multiple stones may be difficult to assess
- Most often used during follow up and pregnancy



Pre-operative Imaging: Non-contrast Enhanced Helical CT (NCCT)

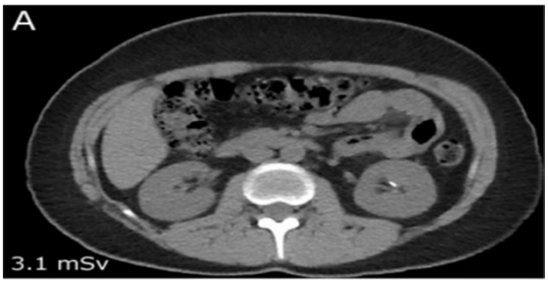
- NCCT
  - Sensitivity approaching 100%
  - Specificity ≈ 97%
  - Readily available at most centers including ER's
  - May identify other intra-abdominal pathology
  - Can assess presence but not *degree* of obstruction



Yilmaz, Eur Rad, 1998; Boulay, AJR, 1999; Chen, J Emerg Med, 1999; Pearle, J Urol, 1999; Pfister, Eur Rad, 2003

Pre-operative Imaging: Low Dose CT (LDCT)

- Ability to significantly decrease radiation exposure
  - 10 mSv reduced to < 3 mSv
- Some limitations with small (< 2 mm) stones and stones in the mid to distal ureter
- Dose reduction less in obese patients (BMI > 30)
- Secondary signs of obstruction, such as perinephric stranding may be more difficult to visualize



Zilberman, J Urol, 2011; Uppot, Rad Rnds, 2011

Surgical Management of Stones

- AUA in 2016 updated their guidelines for the surgical management of stones.
- Primary options remain watchful waiting, shockwave lithotripsy (ESWL), ureteroscopy and laser lithotripsy, and percutaneous nephrolithotomy (PCNL)
- Minimal role for open stone surgery in 2016

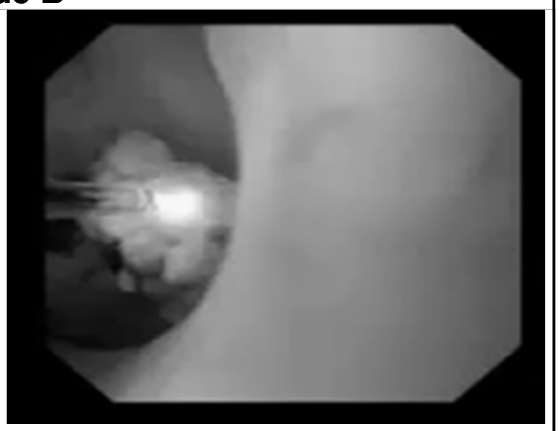
AUA Surgical Stone Guidelines

- Factors considered:
  - Size of stone
  - Location of stone
  - Symptomatic?
  - Hx of infection

Symptomatic Patient with Total Non-Lower Pole Stone Burden < 20 mm: SWL vs URS

Strong Recommendation
Evidence Level Grade B

- Stone-free rates acceptable via SWL and URS
  - Less morbidity than PCNL
- URS associated with lower risk of repeat procedure → stone-free quicker than SWL
- SWL advantage: non-invasive, pt preference, lack of stent
- Requires shared decision-making process

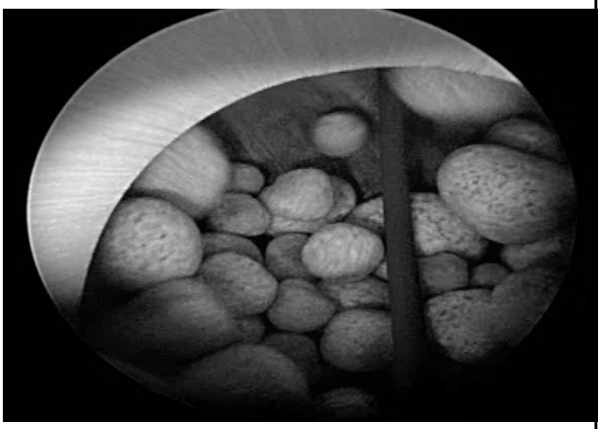


SWL = Shock Wave Lithotripsy URS = UReteroScopy
PCNL = PerCutaneous NephroLithotomy

Symptomatic Patient with Total Non-Lower Pole Stone Burden > 20 mm: PCNL

Strong Recommendation
Evidence Level Grade C

- PCNL has higher stone free rate than SWL or URS
  - Less invasive than open or laparoscopic/robotic surgery
  - Less affected by stone location, composition or density
- Increased invasiveness and risk of complications



SWL = Shock Wave Lithotripsy URS = UReteroScopy
PCNL = PerCutaneous NephroLithotomy

SWL should not be offered as first-line therapy for total renal stone burden > 20 mm

Moderate recommendation
Evidence Level Grade C

- Significantly reduced stone free rates
- Increased need for multiple treatments vs PCNL

- Risk of steinstrasse/ureteral obstruction increases
  - > 2 cm stone → 24.3%
  - 1-2 cm stone → 15.9%
  - < 1cm stone → 4.5%

Extracorporeal shock wave lithotripsy (ESWL) machine

Soyupek et al. Urol Int 2005
Madbouly et al. J Urol 2002
Al-Awadi et al. BJU Int 1999

Staghorn stones

Clinical Principle

- Should be removed if attendant co-morbidities do not preclude treatment
  - Risk for deterioration of renal function
  - Loss of kidney
  - ESRD
  - Infectious complications
  - Mortality

- Older series more infection stones
- Newer series more metabolic stones

Symptomatic ≤ 10 mm Lower Pole Renal Stones

Strong Recommendation
Evidence Level Grade B

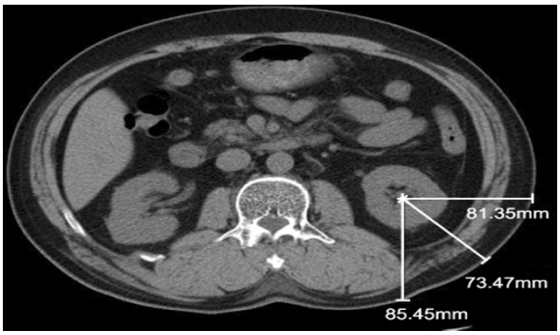
- First-line therapy:
  - SWL
  - URS
- Multi-center, prospective RCT
  - No statistically significant difference in stone free rates
  - Intraop complications slightly higher with URS
  - Pt derived QOL measures better with SWL

Pearle et al. J Urol 2005

Symptomatic ≤ 10 mm Lower Pole Renal Stones

Strong Recommendation
Evidence Level Grade B

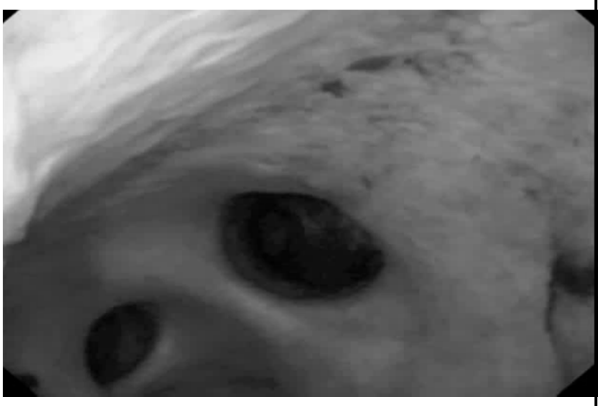
- CT imaging parameters to aid in pt selection
  - Skin-to-stone distance
    - > 9-10 cm → URS
    - < 9-10 cm → SWL
  - Stone attenuation
    - > 900-1000 HU → URS
    - < 900-1000 HU → SWL



> 10 mm Lower Pole Renal Stones

Strong Recommendation
Evidence Level Grade B

- First-line therapy:
  - URS or PCNL
  - Both have better stone free rate than SWL
  - Moderate associated increase in risk with PCNL
- Should not offer SWL as first-line therapy
- URS and SWL
  - Higher re-treatment rates
  - SFR significantly lower
  - Higher likelihood of clinical recurrence due to retained fragments

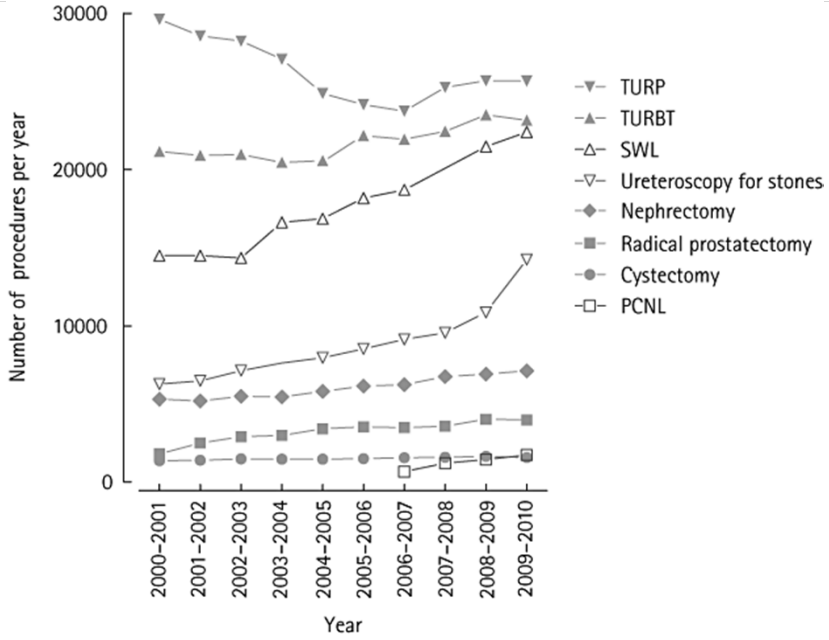


Asymptomatic Non-obstructing Caliceal Stones

Conditional Recommendation
Evidence Level Grade C

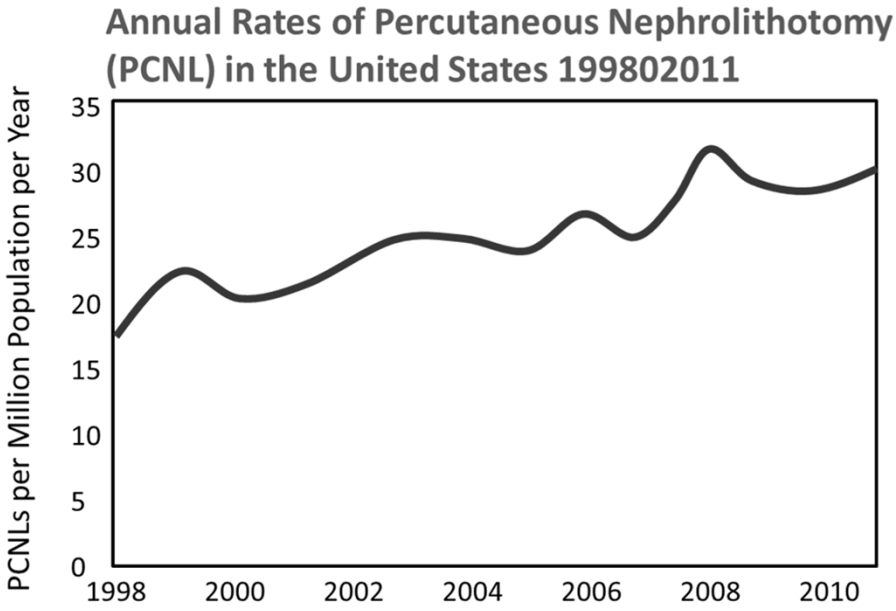
- Clinicians may offer active surveillance
- Counsel pts
  - Risk of stone growth
  - Passage
  - Pain
- Serial imaging
- Dietary modifications
- Medical therapy

Increase in URS Procedures



Turney, B. W., Reynard, J. M., Noble, J. G. and Keoghane, S. R. (2012), Trends in urological stone disease. BJU International, 109: 1082–1087. doi:10.1111/j.1464-410X.2011.10495.x

Increase in PCNL Procedures



Stern, Urol, 2016 - http://dx.doi.org/10.1016/j.urology.2015.12.080

Conclusions

- Common condition with 1:11 American's experiencing stone in their lifetime
- Imaging highly sensitive with focus now on reducing radiation exposure
- ESWL, URS with laser lithotripsy, and PCNL remain cornerstones of surgical therapy

Kidney Stones:
Medical Management and Prevention

Ganesh Shidham, MD
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The Ohio State University Wexner Medical Center

Outline

- Types of Kidney stones
- Evaluation
- Identify Risk factors for kidney stone
- Medical management
  - Treatment of risk factors

Types of Stones

Type	Frequency %	Characteristics
Calcium Stones	70-88	M>F, radiodense
Oxalate	36-70	in acidic pH
Phosphate	6-20	in alkaline pH
Mixed	11-31	

Types of Stones

Type	Frequency %	Characteristics
Non-Calcium Stones 22-30%		
$MgNH_4PO_4$ (Struvite) Triple phosphate	6-20	F>M, radiodense, staghorn, alkaline pH >8, infection with urea splitters (proteus)
Uric Acid	6-17	M>F, radiolucent, acidic pH
Cystine	0.5-3	F>M in homozygotes, radiodense, acidic pH
Rare stones	Rare	Xanthine, triamterene, indinavir, ephedrine

Who To Investigate?

Active stone disease and *recurrent* stone formers : need full work up

- Metabolic abnormalities in 96% (Levy et al)

First time stone former:

- Large stone, Needing urologic procedure, Needing hospital stay, complicated by sepsis : should get complete evaluation
- Small stone passed spontaneously: Limited w/u is sufficient with increase in fluid intake.

Evaluation
Clinical

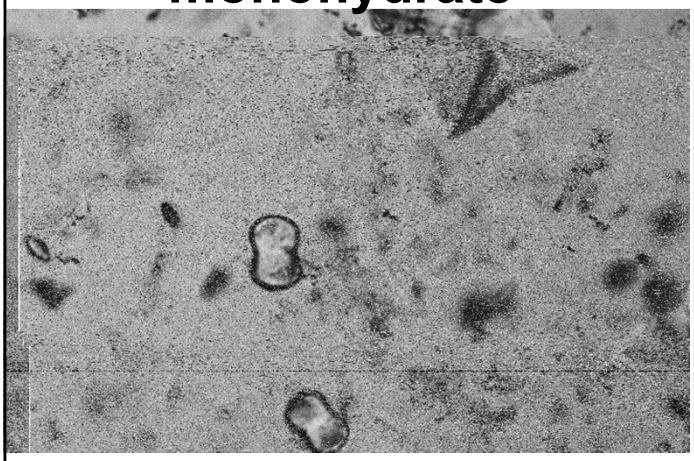
Detailed evaluation is best postponed until free of symptoms and eating normally.

- Dietary history: fluid, protein, oxalate, Na, Calcium
- Medications
- Family history (significant risk for recurrence)
- Medical illnesses: Recurrent UTI, IBD, gout, neoplasm, HPTH, hyperthyroidism, RTA
- Previous stones and interventions
- Is the disease active?

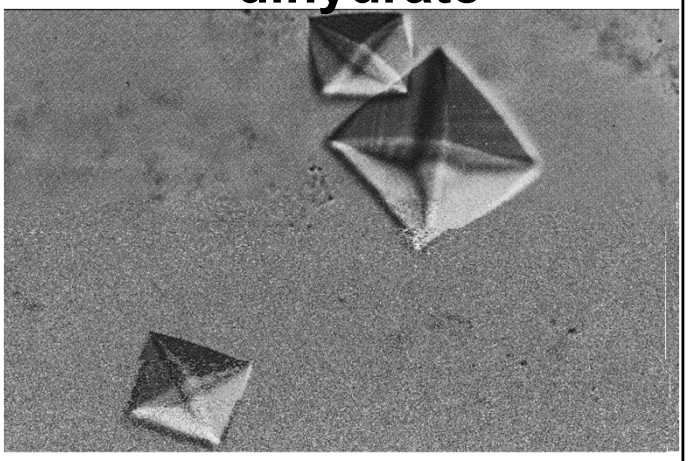
Evaluation
Lab Studies

- Stone analysis
- Blood profile
- Urine metabolic evaluation
- Urine Microscopy - crystals
- Imaging: (for baseline stone burden)
    - CT scan with stone protocol
    - US kidney
    - KUB

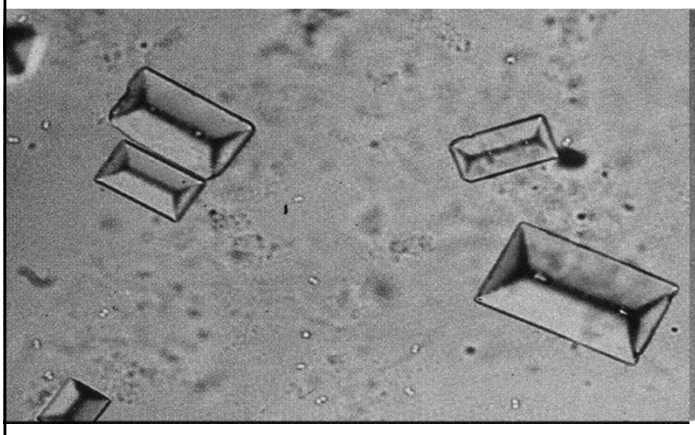
Cal Ox monohydrate



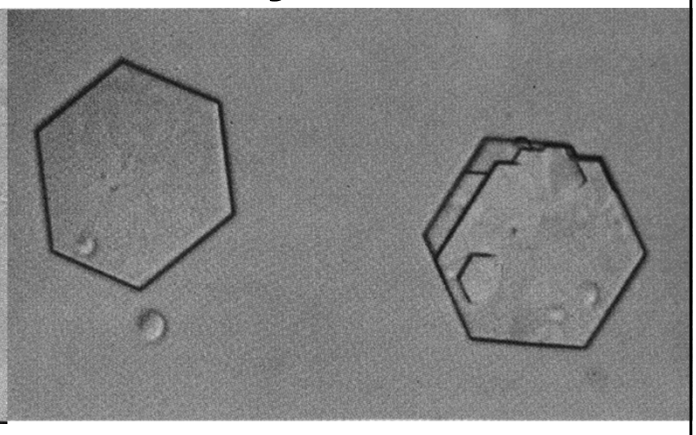
Cal Ox dihydrate



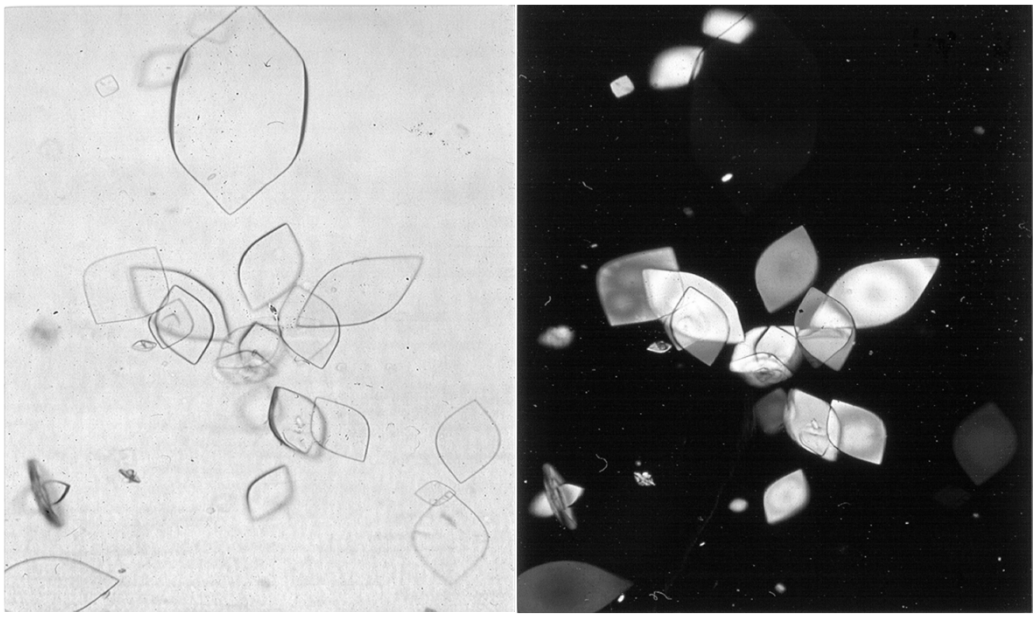
Struvite



Cystine



Uric Acid



Evaluation

24-Hour Urine Testing

- Volume
- pH
- Calcium
- Oxalate
- Uric Acid
- Citrate
- Sodium
- Potassium
- Creatinine
- Urea
- Phosphorus
- SS CaOx
- SS CaP
- SS Uric acid

Summary Stone Risk Factors

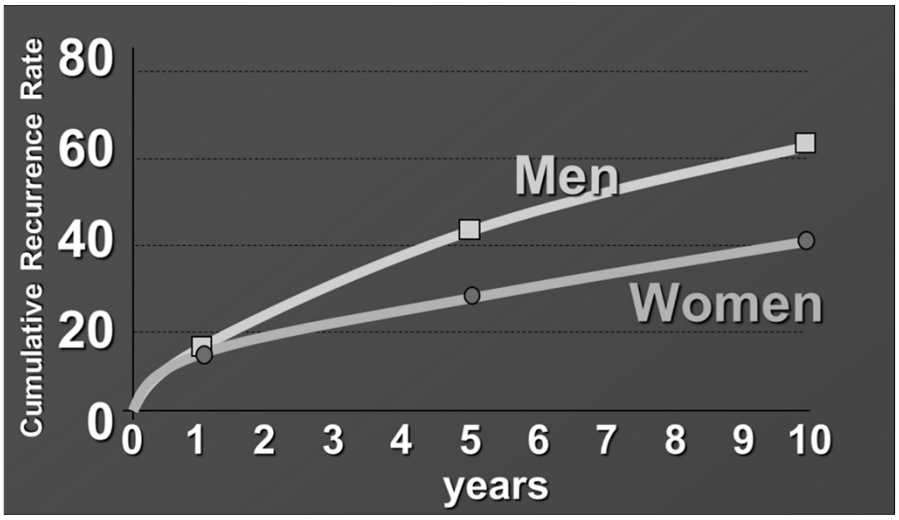
SAMPLE ID: **S809652** PATIENT COLLECTION DATE: **03/02/2011**

ANALYTE	← DECREASED RISK — INCREASING RISK FOR STONE FORMATION →
Urine Volume (liters/day)	2.25
SS CaOx	3.16
Urine Calcium (mg/day)	183
Urine Oxalate (mg/day)	23
Urine Citrate (mg/day)	214
SS CaP	0.17
24 Hour Urine pH	5.448
SS Uric Acid	1.10
Urine Uric Acid (g/day)	0.504

Report from Litholink Laboratory

Recurrence of Stones

Recurrence rate after first kidney stone

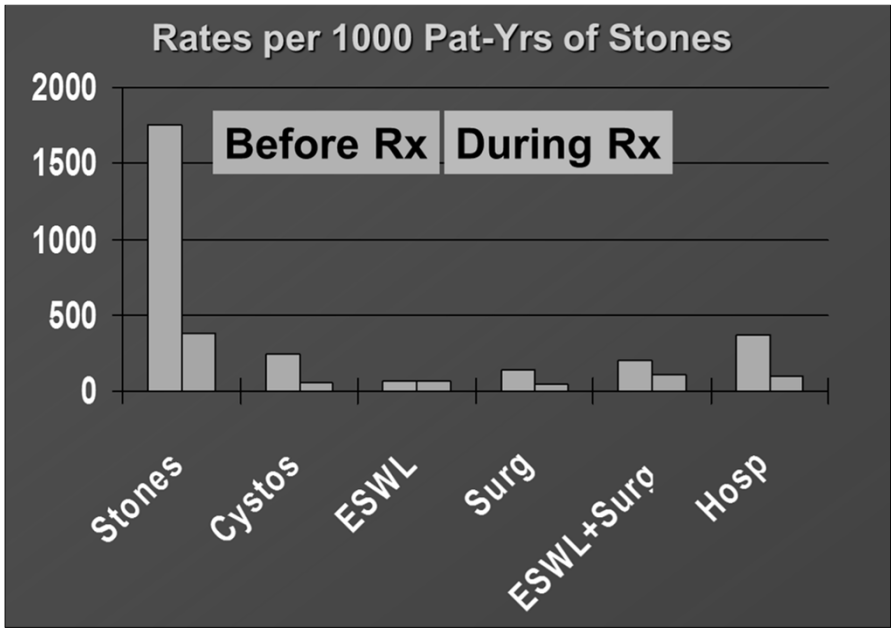


Recurrence 5% per year if untreated

Uribarri, et al, Ann Intern Med 1989; 111;1006

Medical Management

Before and During Medical Treatment



Data from Parks & Coe, 1996. University of Chicago

Risk Factors for Calcium stones

1.Hypercalcuria (40-75%)
- A. With hypercalcemia
  - Hyperparathyroidism
  - Granulomatous diseases
  - Hyperthyroidism
  - Malignancies, Immobilization
- B. Without Hypercalcemia
  - Type 1 RTA
  - High protein intake, High salt intake
  - **Idiopathic Hypercalciuria** (most common)

Risk Factors for Calcium stones

2. Hyperuricosuria (30-50%)
   - Purine rich diet, gout, alcohol,
   - Metabolic syndrome, Inborn errors
3. Hypocitraturia (10-50%)
   - Type 1 RTA
   - Diarrheal diseases
   - High dietary animal proteins

Risk Factors for Calcium stones

4. Hyperoxaluria (<5%)
   - Primary hyperoxaluria
   - Enteric hyperoxaluria (malabsorption)
   - Post Bariatric surgery
   - Oxalate rich foods, Ascorbic acid
5. Anatomic risk factors:
   - Medullary Sponge kidney
   - Horseshoe Kidney
   - Polycystic Kidney disease

Risk Factors for Calcium Stone

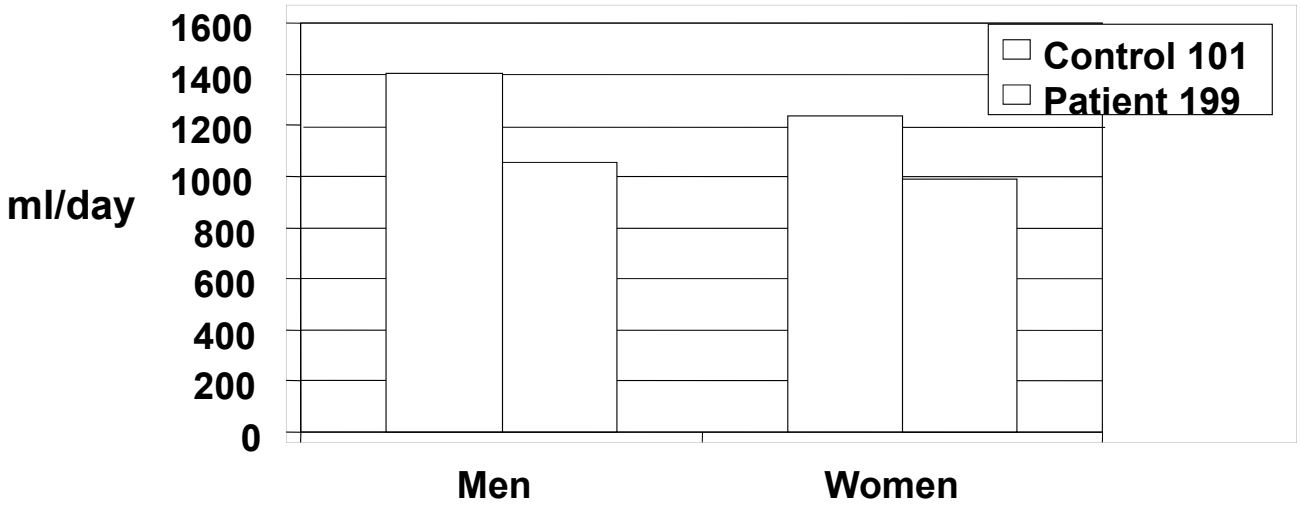
1. Low Urine Volume
2. Hypercalcuria
3. Hyperoxaluria
4. Hypocitraturia
5. High Na intake
6. High protein intake
7. Hyperuricosuria

Treatment of Risk Factors

Low Urine Volume

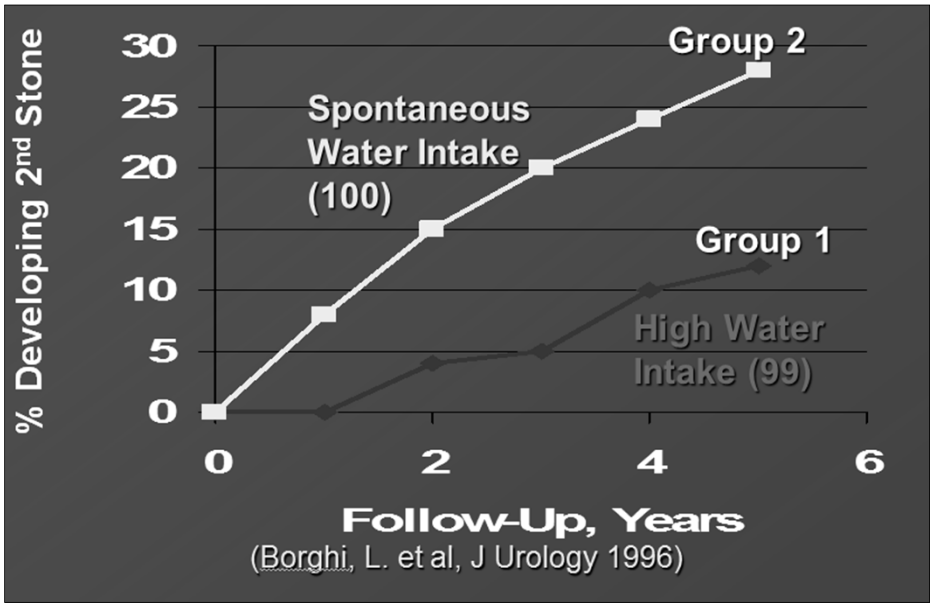
Definition	**Urine output < 1 L/day**
Treatment	**- Increase water intake.** **- Avoid sugar, salt, or Phosphoric acid containing carbonated beverage**
Goal	**Urine volume >2 L /day**

Urine Volumes in Kidney Stone Patients



(Borghi, L. et al, J Urology 1996)

Effect of Increased Water on Stone Recurrence



Case 1

56 y man with CaOx stones. Passed multiple stones since 2005. ESWL in 2005 for right sided stone, ESWL 2009 for left sided stone.

Serum	Na	K	Cl	CO2	Creat	Ca	Mg	P
2/2/09	139	4.3	105	26	0.9	11.8	2.1	1.9

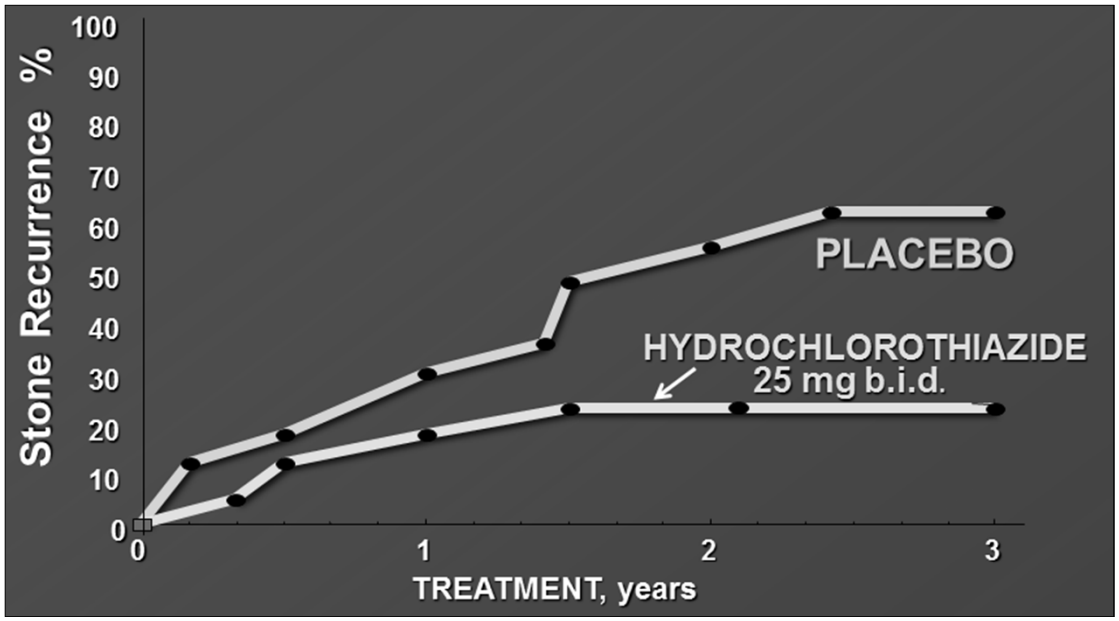
Urine	Vol24	Ca24	Ox24	Cit24	UpH	Cr24	Na24	UA24	CaOxSS
2/2/09	1.81	402	37	712	6.3	1700	134	0.64	8.2
Normal	2.00	<250	20-40	>450	5.8-6.2		50-150	<0.80	4-6

Next appropriate test?
What therapy is appropriate?

Treatment of Risk Factors
Hypercalciuria

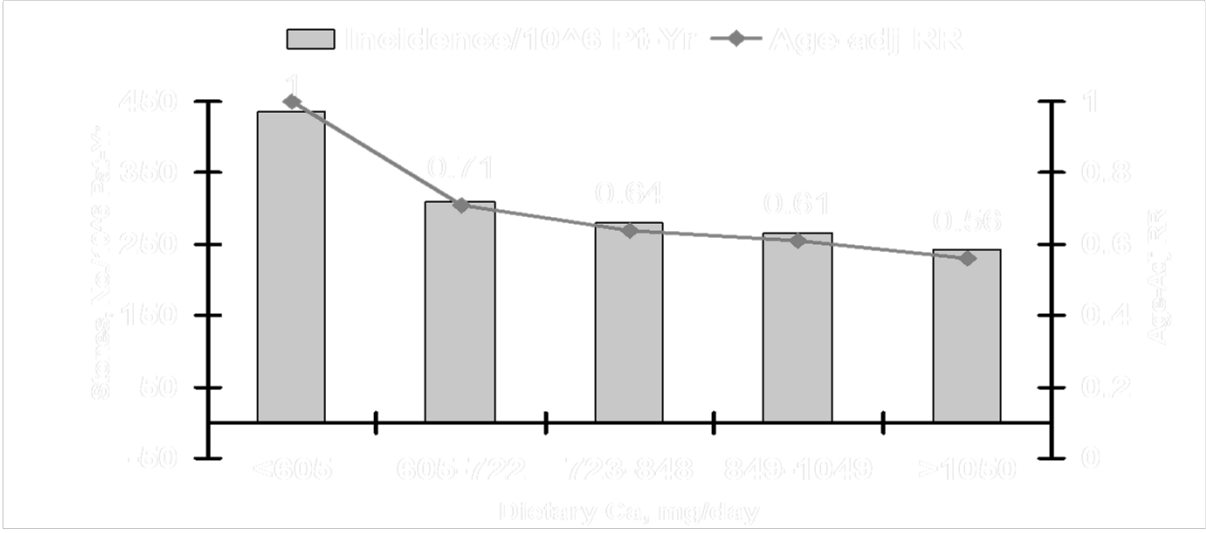
Definition	**Urine Ca > 4 mg/kg/day**
Treatment	**1.Urine output >2 L/day** **2.↓ dietary protein & NaCl** **3.HCTZ 25 mg PO BID (↓Urine Ca by 40-60%)** **4.Maintain normal Ca diet** **5.Avoid Calcium supplements**
Goal	**Urine Ca < 4 mg/kg/day**

Hypercalciuria: Thiazides & Stone Recurrence



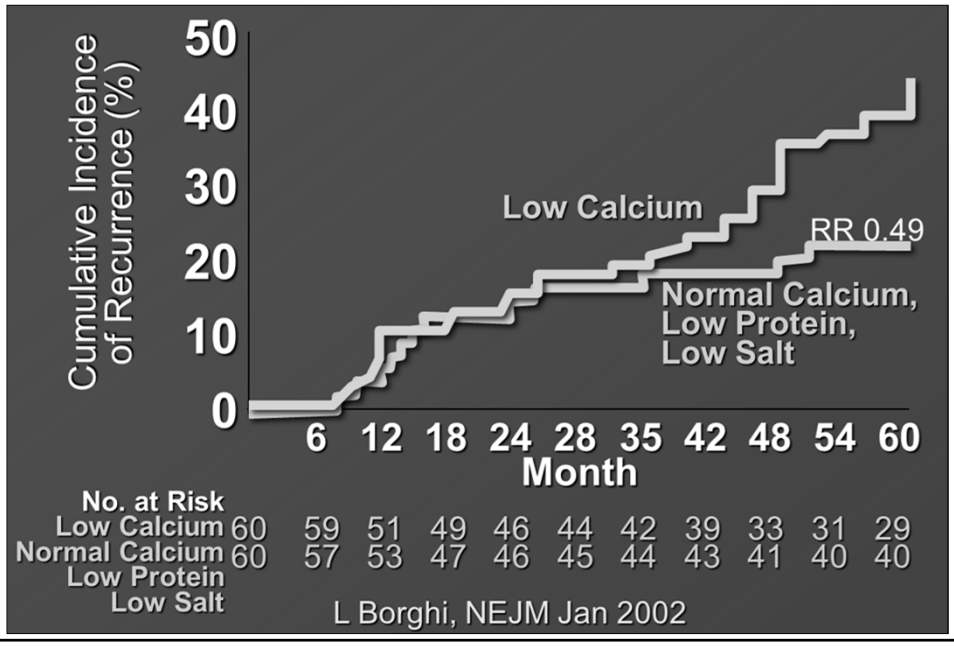
Laerum & Larsen, Acta Med Scand 1984

Myth: *High Calcium Intake Leads to Kidney Stones*



Curhan, NEJM 1993

Hypercalciuria: Recurrent Stones According to Diet



Treatment of Risk Factors
Hyperoxaluria

Definition	**Urine oxalate >45 mg/day**
Treatment	**1. Urine Output >2 L** **2. Diet low in oxalate, ascorbic acid** **3. Calcium supplements**
Goal	**Urine Oxalate < 45 mg/day**

Case 2

21 yrs old man with H/O kidney stones.
He has CT scan showing bilateral stones and areas of Nephrocalcinosis.

Serum	Na	K	Cl	CO2	Creat	Ca	Mg	UA
10/6/02	131	4.4	106	15	1.4	9.9	2.2	7.2

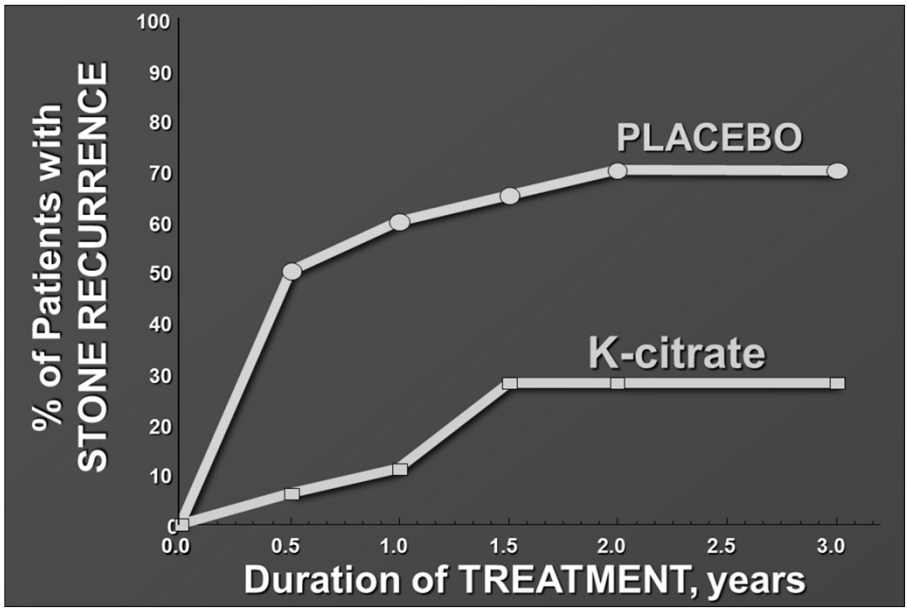
Urine	Vol 24	Ca24	Ox24	Cit24	UpH	Na24	Cr24	UA24	UASS
12/02	1.2	177	31	72	6.8	106	1632	0.599	0.8
12/04	1.02	144	30	82	6.5	117	1566	0.654	1.0
Normal	2.00	<250	20-40	>450	5.8-6.2	50-150	varies	<.800	0-1

Where is the problem?
What is the treatment?

Treatment of Risk Factors
Hypocitraturia

Definition	**Urine citrate <350 mg/day**
Treatment	**1. Urine output > 2 L/day** **2. K Citrate 20 mEq TID** **3. Normal protein diet** **4. Sod Bicarbonate**
Goal	**Urine citrate >350 mg/day** **Normal plasma Bicarb**

Effect of K-Citrate on Stone Recurrence



Barcelo P, J Urolo 1993

Treatment of Risk Factors
High Na+ Intake

Definition: Urine Na >100 mmol/day

Effect: -Urinary Ca

Treatment: Low salt diet
(<100 mmol sodium/day)
(<2 gm sodium/day)

Goal: Urine Na < 100 mmol/day

Case 3 ////// add

34 yo body builder male with H/O renal colic. Passed two stones in 1998. Had 4 episodes of kidney stones since then.

Serum	Na	K	Cl	CO2	Creat	Ca	Mg	UA
10/6/01	141	4.4	106	28	0.9	9.9	2.2	7.2

Urine	Vol24	Ca24	UUN	Cit24	UPO4	Cr24	Na24	UA24	UASS
10/01	1.1	319	24	323		2401	253	1.50	3.4
7//01	1.0	298	26	212		2427	242	1.44	3.9
Normal	2.0	<250		>450			50-150	<0.80	0-1

Treatment of Risk Factors
High Protein Intake

Definition Dietary Protein > 1gm/kg

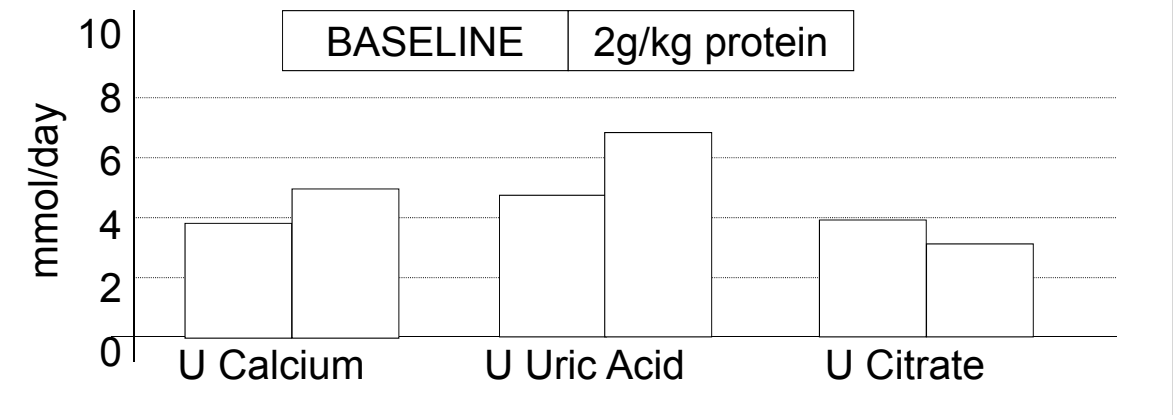
Effect Increases Urine Ca, Uric acid and decreases Citrate

Treatment Decrease intake of animal protein

Goal Protein intake ~ 1g/kg

Estimated dietary protein
= 6.25(24 hr urine urea nitrogen in gm + 0.03/kg body weight)

Protein Load Increases Urine Stone Forming Tendency

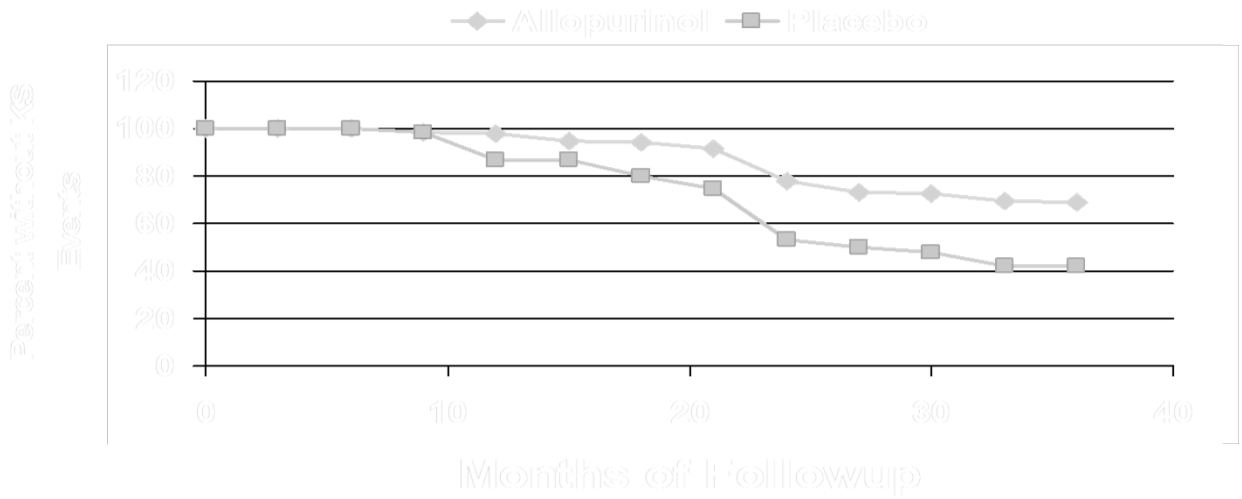


J Cli Endocrinol Metab 1990;71:861

Treatment of Risk Factors
Hyperuricosuria

Definition	**Urine uric acid >750 - 800 mg/day**
Effect	**Nucleation of CaOx on uric acid**
Treatment	**1. ↓ dietary purines** **2. Alkaline urine pH ~ 6.5** (Solubility of uric acid- Acidic urine - 100 mg/L At pH 7 – 1600 mg/L) **3. K Citrate** **4. Allopurinol**
Goal	**Urine uric acid < 750-800 mg/day**

Allopurinol in Hyperuricosuric Ca Stone Formers



Ettinger et al, 1988

Non Calcium stones

- **Uric acid stones**
- **Struvite/Infection stones**
- **Cystine stones**

Take Home Messages
Hard Facts About True Grit

- Nephrolithiasis is Common disease causing fair amount of morbidity & large economic burden
- Systemic disease associated with HTN, Obesity, DM, CAD, Metabolic syndrome and bone disease
- Identifying risk factors is important
- Simple treatments –like dietary & fluid modification can slow or prevent future stone development
- Increasing fluid intake to make > 2 Lts of urine per day is first line of treatment for stone preventions