‘HOW BIG ARE YOUR STONES....DAVID?’

A Renal Colic Presentation by Brian Ramrattan
OBJECTIVES

Epidemiology

- Identify common risk factors for renal stone disease
- Know the common types of renal stones
- Identify common signs and symptoms for renal stone disease
- Familiarize with basics of renal stone management, including knowing when to consult urology
Nephrolithiasis is estimated to produce medical costs of $2.1 billion per year in the US.

Incidence is 0.5%.

Prevalence is 5.2%.

Peak onset 20 - 35 years of age.

Male:Female 3 - 4 : 1.
In their lifetime

2 - 5% of the Asian population

8 - 15% of North Americans and Europeans

20% of Saudi Arabians will develop a kidney stone
Soucie et al performed a cross sectional study to investigate the geographic variability in the rates of stone formation.

1,167,009 men and women in the U.S.

Stones were 2x as prevalent in the southeast.

Ambient temps and sunlight indices were independent predictors of stone formation.
Curhan et al studied the influence of FH on stone formation

17.2% of men vs. 6.4% + family history

1986 - 1994: 795 incident cases of stones

RR of stone formation in men with +FH 2.57 (95% CI 2.19 - 3.02)
Serio and Fraioli confirmed hereditary predisposition.

22.5% of patients who developed stones in Italy between 1993 - 1994 had a positive FH in one or both of their parents.
NATURAL HISTORY RECURRENCE RATES

40 % in 2 - 3 years

55% in 5 - 7 years

75% in 7 - 10 years

100% in 15 - 20 years
RISK FACTORS

PMx and FHx
Enhanced enteric oxalate absorption
  Gastric bypass, short bowel syndrome
Patient factors
  HTN, obesity, gout, DM, extreme exercise, poor oral fluid intake
Recurrent upper UTIs
UTI due urease-producing organisms (Protease, Klebsiella) increases risk of struvite stones
Persistently acidic urine
  Chronic diarrhoea, metabolic disorders (gout, DM, obesity)
Meds: Lasix, glucocorticoids, theophylline, calcium, vitamins A, C, and D
TYPES OF STONES

- Calcium Oxalate and **Calcium Phospate** (60-70%)
- Struvite (10-15%)
- Uric Acid (10-15%)
UNCOMMON TYPES OF STONES

- Calcium citrate
- Calcium Carbonate
- Ammonium Urate (Laxative abuse)
Xanthine

2,8-dihydroxyadenine

adenine phosphoribosyltransferase (APRT)

Alcaptonuria

homogentisate 1,2-dioxygenase

Cystine (1%)
dibasic AA transporter

Hereditary Disorders

• Polycystic kidney Disease
• Medullary Sponge Kidney
• Horseshoe kidney
Drugs & Metabolites (<1%)

- Amorphous silica (magnesium trisilicate)
- Guaifenesin Metabolite
- Methylglucamine Iothalamate
1- supersaturation of the urine by stone-forming constituents

Crystals or foreign bodies can act as nidi, upon which ions from the supersaturated urine form microscopic crystalline structures.
RANDALL PLAQUE

• Is deposition of stone material on a renal papillary calcium phosphate nidus

• Calcium phosphate precipitates in the basement membrane of the thin loops of Henle, erodes into the interstitium, and then accumulates in the subepithelial space of the renal papilla

• The subepithelial deposits, eventually erode through the papillary urothelium
HYPERCALCIURIA

- Most common metabolic abnormality

- Can be subdivided into absorptive, resorptive, and renal-leak categories
ABSORPTIVE HYPERCALCIURIA

- Related to increased intestinal absorption of calcium (associated with excess dietary calcium and/or overactive calcium absorption mechanisms)

- The treatment may include modest dietary calcium restriction, thiazide diuretics, oral calcium binders
RESORPTIVE HYPERCALCIURIA

- Related to excess resorption of calcium from bone (i.e., hyperparathyroidism)
- Treatment requires parathyroidectomy
RENAL-LEAK HYPERCALCIURIA

• Less common than absorptive hypercalciuria

• Related to an inability of the renal tubules to properly reclaim calcium in the glomerular filtrate

• Usually associated with secondary hyperparathyroidism and is best managed with thiazide diuretics
• Indiscriminate dietary calcium restriction is not advantageous.

• The reduced dietary calcium reduces the oxalate-binding sites in the gastrointestinal tract, increasing the free dietary oxalate and leading to increased oxalate absorption.
HYPEROXALURIA

- Primary (rare genetic disease)
- Enteric
- Dietary
Type I mutation of AGXT gene on chromosome 2 that codes for alanine glyoxylate aminotransferase

Type II mutation of GRHPR gene on chromosome 9 that codes for glyoxylate reductase and hydroxypyruvate reductase.
ENTERIC

- Due to malabsorption
- Associated with chronic diarrhea or short bowel syndrome
- Normally, calcium binds to intestinal oxalate reducing its absorption
<table>
<thead>
<tr>
<th>Foods high in oxalate and purine</th>
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</thead>
<tbody>
<tr>
<td>High Oxalate Foods (avoid in setting of hyperoxaluria)</td>
</tr>
<tr>
<td>Green beans</td>
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<tr>
<td>Beets</td>
</tr>
<tr>
<td>Celery</td>
</tr>
<tr>
<td>Green onions</td>
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<tr>
<td>Leaks</td>
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<tr>
<td>Leafy greens: collard greens, dandelion greens, Swiss chard, spinach, escarole, mustard greens, sorrel, kale, rhubarb</td>
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<tr>
<td>Cocoa</td>
</tr>
<tr>
<td>Chocolate</td>
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<tr>
<td>Black tea</td>
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<tr>
<td>Berries: blackberries, blueberries, strawberries, raspberries, currants, gooseberries</td>
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<tr>
<td>Orange peel</td>
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<tr>
<td>Lemon peel</td>
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<tr>
<td>Dried figs</td>
</tr>
<tr>
<td>Summer squash</td>
</tr>
<tr>
<td>Nuts, peanut butter</td>
</tr>
<tr>
<td>Tofu (bean curd)</td>
</tr>
<tr>
<td>High Purine Foods (avoid in setting of hyperuricosuria)</td>
</tr>
<tr>
<td>Organ meats: sweetbreads, liver, kidney, brains, heart</td>
</tr>
<tr>
<td>Shellfish</td>
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<tr>
<td>Meat: beef, pork, lamb, poultry</td>
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<tr>
<td>Fish: anchovies, sardines (canned), herring, mackerel, cod, halibut, tuna, carp</td>
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<tr>
<td>Meat extracts: bouillon, broth, consommé, stock</td>
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<tr>
<td>Gravies</td>
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<tr>
<td>Certain vegetables: asparagus, cauliflower, peas, spinach, mushrooms, lima and kidney beans, lentils</td>
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</table>

Figure 54.7 Foods high in oxalate and purine.
HYPERURICOSURIA

- Predisposes to the formation of calcium-containing calculi because sodium urate can produce malabsorption of macromolecular inhibitors

- Can serve as a nidus for the heterogeneous growth of calcium oxalate crystals

- Therapy involves potassium citrate supplementation, allopurinol, or both
URIC ACID STONES

• Exists in equilibrium with urate at a pH of 5.5

• As pH falls below 5.5, concentration of undissociated uric acid greatly exceeds that of urate

• High BMI, glucose intolerance and overt DM 2 are common in uric acid stone formers
<table>
<thead>
<tr>
<th>Uric acid stones</th>
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</thead>
<tbody>
<tr>
<td>Low Urine pH (≤ 5.5)</td>
</tr>
<tr>
<td>High animal protein diet</td>
</tr>
<tr>
<td>Diarrhea</td>
</tr>
<tr>
<td>Insulin resistance (high body mass index, metabolic syndrome, type 2 diabetes)</td>
</tr>
<tr>
<td>Low Urine Volume</td>
</tr>
<tr>
<td>Inadequate fluid intake</td>
</tr>
<tr>
<td>Excessive extrarenal fluid losses</td>
</tr>
<tr>
<td>Diarrhea</td>
</tr>
<tr>
<td>Insensible losses (e.g., perspiration)</td>
</tr>
<tr>
<td>Hyperuricosuria</td>
</tr>
<tr>
<td>Excessive dietary purine intake</td>
</tr>
<tr>
<td>Hyperuricemia</td>
</tr>
<tr>
<td>Gout</td>
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<tr>
<td>Intracellular-to-extracellular uric acid shift</td>
</tr>
<tr>
<td>Myeloproliferative disorders</td>
</tr>
<tr>
<td>Tumor lysis syndrome</td>
</tr>
<tr>
<td>Inborn errors of metabolism</td>
</tr>
<tr>
<td>Lesch-Nyhan syndrome</td>
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<tr>
<td>Glucose-6-phosphatase deficiency</td>
</tr>
</tbody>
</table>

**Figure 54.15 Uric acid stones.**
STRUVITE STONES

• Form in chronic upper urinary tract infection due to a urease-producing organism

• Are composed of magnesium ammonium phosphate (struvite) and calcium carbonate-apatite

• Normal urine is undersaturated with ammonium phosphate, and struvite stone occurs only when ammonia production is increased and the urine pH is elevated to decrease the solubility of phosphate
STRUVITE STONES

• May grow rapidly over a period of weeks to months can develop into a staghorn calculus involving the entire renal collecting system
CLINICAL PRESENTATION

• Renal colic begins suddenly and intensifies over 15 - 30 minutes

• Associated with nausea & vomiting

• Pain passes from the flank anteriorly to the groin

• At the ureterovesicular junction, urinary frequency and dysuria may occur

• Microscopic hematuria > 75%, gross - 18%
DIFFERENTIAL DIAGNOSIS

- Renal cell carcinoma
- Pyelonephritis
- Gynae - ectopic pregnancy/cyst accident, dymenorrhoea
- Surgical - bowel obstruction, mesenteric ischaemia, appendicitis, diverticulitis
- Biliary colic/cholecystitis
- Herpes zoster
- AAA
DIAGNOSIS

- Non-con helical CT
  - 3-5mm cuts
  - May identify alternative diagnosis
  - Some information regarding stone compostiosn
  - Radiation dose
    - Low dose CT have similar sensitivity and specificity except with small (<2mm) stones and in obese patients

- USS
  - No radiation
  - Sensitive for obstruction
  - May be able to identify radiolucent stones
  - Harder to detect smaller stones and distal ureteric stones
CT scan shows a calculus in the proximal left ureter causing delayed excretion of contrast material from the left kidney (long arrow). All the contrast has been excreted from the normal functioning right kidney and is in the nondilated right ureter (small arrow).

CT scan: computed tomographic scan.

Courtesy of Jonathan Kruskal, MD.
Kidney stone detected by ultrasonography

The sagittal view of the right kidney reveals a 7 mm shadowing stone in mid-portion of the kidney, characteristic of a non-obstructing stone. The echogenic focus (white arrow) represents the stone. The calcified stone inhibits transmission of sound waves, resulting in a shadow behind the stone (red arrows).
USS V CT IN THE ED

SMITH-BINDMAN, AUBIN, BAILITZ, ET AL. ULTRASONOGRAPHY VERSUS COMPUTED TOMOGRAPHY FOR SUSPECTED NEPHROLITHIASIS. NEJM 2014;371:1100.

- Pts with clinical suspicion of renal colic randomised to non-con CT, USS by radiologist, bedside USS by trained ED physician
- Sensitivity
  - USS 57% (radiologist), 54% (ED physician)
  - CT 88%
- Radiation dose higher in CT group
- Significant missed diagnoses similar
  - USS 0.5%, CT 0.3%
- Adverse events & repeat visits to ED similar
- Length of stay in ED longer when USS performed by Radiologist
OTHER IMAGING MODALITIES

• AXR/XR KUB
  • Will detect large radiopaque stones
  • Potential to miss uric acid stones, smaller stones and stones overlying bone
  • Does not detect signs of obstruction

• IVP
  • More specific and sensitive the plain XR
  • Detects obstruction
  • Potential for contrast reactions, significant radiation dose

• MRI
  • Some role in pregnancy
Intravenous pyelogram showing ureteral stone

An image obtained during the excretory phase of an intravenous pyelogram shows contrast material in the right renal pelvis and ureter extending down to the mid-ureter where a small calculus is obstructing the lumen (arrow).

*Courtesy of Jonathan Kruskal, MD.*
The plain film of the abdomen in the anteroposterior projection reveals a staghorn calculus. Note calcifications (arrows) in the opposite kidney as well.
### Radiologic procedures in evaluating renal stones

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>KUB</td>
<td>Readily available</td>
<td>Requires skilled radiologist to interpret</td>
</tr>
<tr>
<td></td>
<td>Inexpensive</td>
<td>Limited sensitivity and specificity</td>
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<tr>
<td></td>
<td>Limited radiation</td>
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<td></td>
<td>Useful in acute setting</td>
<td></td>
</tr>
<tr>
<td>Ultrasound</td>
<td>Readily available</td>
<td>Moderately expensive</td>
</tr>
<tr>
<td></td>
<td>Roughly equivalent to IVP as a diagnostic test</td>
<td>Poor performance with small stones</td>
</tr>
<tr>
<td></td>
<td>Improved sensitivity with use of color Doppler</td>
<td></td>
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<tr>
<td></td>
<td>No radiation exposure</td>
<td>Requires skilled technician and radiologist</td>
</tr>
<tr>
<td></td>
<td>Good for hydronephrosis</td>
<td></td>
</tr>
<tr>
<td>Excretory urography (IVP)</td>
<td>Useful in planning therapy and confirming diagnosis</td>
<td>Moderately expensive Intravenous contrast required</td>
</tr>
<tr>
<td></td>
<td>Long established history as gold standard</td>
<td>Moderate x-ray exposure</td>
</tr>
<tr>
<td>CT scan (including spiral CT)</td>
<td>Probably new gold standard</td>
<td>Expensive</td>
</tr>
<tr>
<td></td>
<td>Can distinguish radiolucent stones from blood or tumor</td>
<td>Moderate x-ray exposure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not uniformly available</td>
</tr>
<tr>
<td>MRI</td>
<td>Great potential for localizing site of stone in ureter</td>
<td>Very expensive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely investigational so far except in certain centers</td>
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<tr>
<td></td>
<td></td>
<td>Poorly tolerated by many patients</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stones are not affected by magnet and may be missed</td>
</tr>
</tbody>
</table>
• Analgesia and hydration
  • NSAIDs v opiates
    • NSAIDs can reduce smooth muscle tone in the ureter
    • Possibly best in combination
    • NSAIDs should be avoided/used with care in severe dehydration and impaired renal function
PASSING A STONE

- <5mm likely to pass without intervention
- >10mm unlikely to pass without intervention
- Increased intervention requirements with larger stones
- Likelihood of stone passing also affected by position
  - Stones at the vesicoureteric junction more likely to be passed than those in the proximal ureter
MEDICAL EXPULSIVE THERAPY

• Alpha-blockers - prazosin, tamsulosin (tamsulosin is a selective $\alpha_{1A}$ receptor blocker so less SEs than with prazosin but cost implications as not on some health system formularies)

• (Calcium channel blockers - nifedipine)
UROLOGICAL REFERRAL

- Urosepsis
- AKI
- Anuria
- Uncontrolled pain
- Stones not passed after trial of medical therapy (usually about 4 weeks)
INTERVENTION

• Emergency
  • infected obstructed kidney, bilat obstruction with AKI or obstructed single kidney with AKI requires urgent decompression via percutaneous drainage or ureteric stenting
  
• Shock wave lithotripsy
  
• Ureteroscopic lithotripsy
  
• Percutaneous nephrolithotomy with laparoscopic stone removal

• Open surgical removal
SURGICAL MANAGEMENT

PROXIMAL URETER

- Antegrade Nephroureterolithotomy
- Retrograde Ureteroscopy
- ESWL
- Stenting Alone
- Percutaneous Ureterolithotomy
- Nephrolithotomy
<table>
<thead>
<tr>
<th>MIUROTER</th>
<th>RETROGRADE URETEROSCOPY</th>
<th>ANTEGRADE NEPHROSTOURETEROLITHOTOMY</th>
<th>OPEN URETEROLITHOTOMY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ESWL</td>
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</table>
SURGICAL MANAGEMENT

DISTAL URETER

- ESWL/ureteroscopy
- Antegrade nephrostoureterolithotomy
- Stenting alone
- Open ureterolithotomy
Acute therapy of symptomatic urolithiasis

Stone radiopaque?
Yes
- Fluids and pain medications
Yes
- Stone > 5 mm
- Strain urine and continue hydration
No
- Stone passes
Yes
- Ultrasound in two weeks if hydronephrosis or multiple stones on initial evaluation
No
- Probable uric acid stone
- Fluids and pain medications
- Alkalinate the urine with potassium citrate

Urologic evaluation

Staghorn calculi
Yes
- Percutaneous lithotomy plus ESWL
No
- Calyceal or upper ureteral calculus
Yes
- ESWL
No
- Distal ureteral calculus
Yes
- Ureteroscopy or ESWL
Clinical Pathway For Suspected Urinary Stones

Flank pain and clinical suspicion of urinary stone
- Obtain urinalysis
- Consider
  - Creatinine
  - BUN

Infection?

IV fluids (Class III) AND
- Analgesics (Class II) AND
- Tamsulosin (Class II)

Pain resolution?

Imaging:
- Adult: Unenhanced CT (Class I)
- Pregnant/pediatric patients: KUB and ultrasound (Class I)

Discharge
- Pain medication
- Follow up with urology

Stone detected?

≤ 7 mm
- Continue analgesics; reassess
- Consult urology if not improving

> 7 mm
- Continue analgesics; reassess
- Consult urology

Consider contrast CT if pathology suspected

Abbreviations: BUN, blood urea nitrogen; CT, computed tomography; IV, intravenous; KUB, kidney, ureter, bladder [imaging]
PREVENTION OF STONE RECURRENCE

• Stone analysis

• Increased fluid intake

• Dietary and lifestyle factors
  • Obesity, diabetes, exercise
  • Low sodium diet for calcium stones
ADDITIONAL TREATMENTS

- Thiazide diuretics in combination with low sodium diet for calcium stones

- Potassium citrate for hypocitraturia and to alkalinise the urine in uric acids stones (also some role for allopurinol in uric acid stone prevention)

- Increased fluid intake, urinary alkalinisation and tiopronin (thiol drug which decreases the precipitation of cystine in the urine) for cystine stones
1. “I dipped his urine, and it was negative for microscopic blood. I figured it was just musculoskeletal back pain and discharged him with muscle relaxants.”
A negative UA for microscopic blood does not exclude urolithiasis. Similarly, a positive UA with red blood cells does not diagnose renal colic.

2. “I was sure a renal calculus was the cause of the patient’s radiating pain, nausea, vomiting, and dysuria, but the CT of her abdomen and pelvis was negative for a kidney stone.”
All stones are not visible on CT. Crystal deposits formed as a result of pure protease inhibitors such as indinavir are not appreciated on CT scans. Additionally, calculi smaller than 3 mm can be difficult to detect. If the history fits, treat as a drug-induced stone.

3. “I discharged the elderly man with a previous medical history of hypertension and diabetes after he presented with severe right flank pain and microscopic hematuria. I performed a bedside ultrasound to rule out AAA and diagnosed urolithiasis. He returned to the ER 1 day later with a perforated appendix.”
The most common alternative diagnoses of renal colic are cholelithiasis (5%), appendicitis (4%), pyelonephritis (3%), ovarian cyst (2%), and abdominal aortic aneurysm with and without rupture (1.4%). Additionally, inflammatory and infectious conditions can cause hematuria. Misdiagnosing older patients with urolithiasis can greatly increase their morbidity and mortality.

4. “I assumed that my 70-year-old patient was tachycardic because of the pain from her kidney stone. She was 99.9°F orally so I didn’t bother to check a rectal temperature. I was surprised to learn that she returned with urosepsis.”
Elderly febrile patients should be admitted and urology consulted. Although pain can cause tachycardia, a further workup should be initiated. Elderly patients with fever can develop altered mental status and hypotension and decompensate quickly.

5. “The 22-year-old male patient reported that his lower back pain was similar to his previous renal colic episodes. After we administered morphine and ketorolac, his pain resolved and we discharged him with urology follow-up. I didn’t even think to examine his testicles and was surprised to learn he actually had testicular torsion.”
A complete genital examination should be performed in patients with symptoms suggestive of renal colic. Testicular or ovarian torsion can present very similarly. Epididymitis, acute cervicitis, or pelvic inflammatory disease can also be confused with kidney stones. Remember to conduct a complete history and physical examination even if patients report similar symptoms previously and that opioids were curative.
6. "I ordered an analysis of the stone composition, 24-hour urine collections (volume, pH, urinary substrates), and a full electrolyte panel for my 30-year-old patient who presented with renal colic for the first time." A detailed metabolic evaluation is not cost-effective and is rarely indicated in the acute setting. An assessment of renal function (blood urea nitrogen and creatinine) is warranted, but further laboratory testing should be done only if indicated.

7. "The majority of stones are calcium-based, so I just ordered a KUB to rule out urolithiasis." While 70% to 75% of all stones are calcareous and radio-opaque, only 60% are visible on plain films. KUBs have a sensitivity of 45% to 59% and specificity of 77% in detecting urinary tract calculi. Thus, utilizing KUBs alone is insufficient to diagnose renal colic; KUBs should always be paired with another imaging modality.

8. "A 12-week pregnant woman presented with severe right flank pain which radiated to her right lower quadrant with right costovertebral angle tenderness. It probably was renal colic, but because of the potential morbidity, I obtained a CT to make sure it wasn’t appendicitis." Ultrasonography is the modality of choice in pregnant patients and children. The calculus itself can be seen or secondary signs of the stone such as hydronephrosis can often be visualized.

9. "My 60-kg patient with renal colic still had pain after 6 mg of morphine. I administered another 6 mg, but then she developed respiratory depression and had to be bagged." Non-steroidal anti-inflammatory drugs relieve acute renal colic pain through prostaglandin-mediated pathways and decreased ureteral contractility. In addition, NSAIDs cause fewer adverse effects than opioids. A combination of morphine and ketorolac offers superior pain relief than either drug alone.

10. "I thought his 7-mm stone would pass spontaneously and didn’t think he needed urology follow-up." Most ureteral calculi smaller than 5 mm will pass spontaneously, typically within 4 weeks from symptom onset. Larger stones will take longer to pass. Stones larger than 7 mm usually require surgical intervention, so emergent urologic consultation is needed.
ANY QUESTIONS???