Nephrolithiasis: epidemiology, medical, and surgical aspects

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BACKGROUND

- Nephrolithiasis – 10% lifetime prevalence worldwide

- Men > women
  - Historical numbers → 2 men to 1 woman
  - Recent numbers → 1.5 men to 1 woman

- 50% recurrence within 10 years of first stone event

BACKGROUND

- Yearly US expenditures in 2000
  - $2.1 billion total
  - $971 million inpatient
  - $607 million outpatient
  - $490 million emergency department

- These cost estimates have dramatically increased in the last decade

BACKGROUND

- Etiology

- Historical perspective
  - Dehydration
  - Abnormal urine chemistries

- Modern perspective
  - Nephrolithiasis as a systemic disease
    - (above still true, but it’s not JUST about the urine anymore)

Sakhaee et al (2012)
NEPHROLITHIASIS AND SYSTEMIC DISEASES

Relationship (often reciprocal) between nephrolithiasis and the following common systemic diseases:

- Hypertension
- Diabetes mellitus
- Metabolic syndrome
- Coronary artery disease

HYPERTENSION

Hypertensive patients develop kidney stones

Cappuccio et al
503 hypertensive men, 8 year f/u
History of hypertension $\rightarrow$ 90% increased risk of developing kidney stones

Borghi et al
260 hypertensive men, 8 year f/u
History of hypertension $\rightarrow$ 500% increased risk of developing kidney stones

HYPERTENSION

Kidney stone patients develop hypertension

Madore et al
> 50,000 men, 15 year f/u
History of nephrolithiasis → 29% increased risk of
developing hypertension

Madore et al
>89,000 women, 15 year f/u
History of nephrolithiasis → 24% increased risk of
developing hypertension

DIABETES MELLITUS

- If you have diabetes, incident stone risk is…
  - Older women 1.29 (1.05-1.58)
  - Younger women 1.60 (1.16-2.21)
  - Men 0.81 (0.59-1.09)

- If you have nephrolithiasis, incident diabetes risk is…
  - Older women 1.33 (1.18-1.50)
  - Younger women 1.48 (1.14-1.91)
  - Men 1.49 (1.29-1.72)
METABOLIC SYNDROME

- Metabolic syndrome – 3 of the following 5
  - diabetes mellitus, HTN, obesity, increased triglycerides, low HDL

- NHANES III → 13000 Americans

- Risk of nephrolithiasis increases with # of metabolic syndrome traits
  - 1 trait – RR 1.27 (0.77-2.10)
  - 3 traits – RR 1.76 (1.08-2.85)
  - 5 traits – RR 1.93 (1.04-3.56)


CARDIOVASCULAR DISEASE

- Patients with history of kidney stones demonstrated increased carotid/bulb wall thickness

- History of kidney stones is associated with increased risk of coronary heart disease in:
  - Younger women (OR 1.18, 95% CI 1.08 to 1.28)
  - Older women (OR 1.48, 95% CI 1.23 to 1.78)
  - NOT IN MEN (or 1.06, 95% CI 0.99 to 1.13)

STONE COMPOSITION

- Stone composition
  - Calcium oxalate (most common); Calcium phosphate (increasing); Calcium based stones ~ 80%
  - Uric acid (diabetic, overweight) ~ 5-10%
  - Cystine (genetic disorder, may present in childhood) ~1%
  - Struvite (recurrent infection) ~3%
  - Miscellaneous others (protease inhibitors, other rx)

METABOLIC EVALUATION

- Who gets a workup?
  - Recurrent stone formers
  - Solitary kidney
  - Urinary diversion
  - Young age
  - Patient preference

- Metabolic stone evaluation
  - chem 7, calcium, PTH, uric acid (if PTH is elevated, check vitamin D!!!)
  - 24-hour urine
    - 2 collections standard, but many obtain only 1
COMMON URINE ABNORMALITIES IN CALCIUM OXALATE STONE FORMERS

- Low urine volume
  - Target 2-3 L fluid intake/day

- Hypercalciuria
  - Idiopathic – treat w/ thiazide (level 1 evidence)
  - Primary hyperparathyroidism – treat w/ endocrine surgery

- Hyperoxaluria
  - 2/3 of oxalate endogenous from liver, 1/3 from diet
  - Spinach, beets, rhubarb, vitamin C (> 1 g/day) contain most oxalate
  - Treat w/ magnesium or calcium supplementation w/ meals
  - Evidence is weak

COMMON URINE ABNORMALITIES IN CALCIUM OXALATE STONE FORMERS

- **Hypocitraturia**
  - Citrate inhibits stone formation
  - Low urine citrate in patients with acidosis, dehydration (i.e. diarrheal syndromes)
  - Treat with potassium citrate (level 1 evidence)
  - Treat with sodium bicarbonate if cannot tolerate potassium

- **Hyperuricosuria**
  - At normal pH, uric acid in the urine facilitates CALCIUM stone formation (at low pH, uric acid stones form)
  - Treat with allopurinol 300 mg po qd (level 1 evidence)

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CALCIUM STONE, HIGH URINE CALCIUM, HIGH PTH

- **Thiazide challenge**
  - In patients with elevated PTH and hypercalciuria, the PTH will NOT CHANGE in response to thiazide if they have primary hyperparathyroidism

  - So, give thiazide x 1 week and recheck PTH – if elevated, refer to endocrine surgery, if normal treat with thiazide

  ***Remember that vitamin D deficiency can also raise PTH (but should not raise urine calcium)***

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URIC ACID STONES

- Uric acid – decreased solubility at lower urine pH
  - Typically a pH problem, not a uric acid problem
  - urine uric acid may be “normal”
  - can be dissolved!
  - More common in obese and diabetic

- Treatment – alkalinize urine, target pH ~ 6.5
  - potassium citrate
  - sodium bicarbonate
  - sodium citrate
  - ***theoretical risk of overalkalinizing urine and precipitating calcium phosphate stones (VERY RARE, but shows up on boards questions)

CYSTINE STONES

- Genetic disorder of amino acid transport
  - cystine solubility in urine ~ 250 mg/L
  - some patients excrete > 2000 mg cystine/day

- Treatment
  - Pharmacotherapy – d-penicillamine, thiola (tiopronin), potassium citrate
  - *****the more alkaline the urine, the more the meds work.
  - If you are not alkalinizing urine, these meds can be ineffective
STRUVITE STONES

- Result of chronic infection w/ urease producing microorganisms
- Mainstay of treatment is complete endourological or surgical removal of stones

Pharmacological treatment
- Acetohydroxamic acid (AHA) – urease inhibitor (level 1 evidence)
  - high side effect profile
- Hydroxyurea – urease inhibitor – no RCTs
- Chronic antibiotic suppression – retrospective data supports, used for poor surgical candidates

HIGH YIELD FACTS - DIET

- Sodium intake – ↑urine calcium
- Spinach, rhubarb, beets, > 1000/day vitamin C
  - ↑urine oxalate
- Protein intake - ↑urine calcium, ↓urine citrate
- Animal protein intake - ↑urine calcium, ↓urine citrate, ↑urine uric acid
- Lemon juice (1/2 cup per day or 2 lemons/day) - ↑urine citrate
WHEN RENAL STONES BECOME URETERAL STONES

- All stones start in the kidney
- Why do they pass to renal pelvis and ureter?
  - ???????
- Which will become lodged in the ureter and not pass into bladder?
  - Size criteria are “useful” but not definitive
- Once in bladder, patient is “safe”

URETERAL STONES

- Stone diameter is most significant predictor of passage
  - < 4 mm → 80%
  - 4-6 mm → 59%
  - > 6 mm → 21%
- Alpha blocker recommended for ALL stones < 1 cm that are managed expectantly
  - Significant increase in passage rates
URETERAL STONES: WHERE DO THEY GET STUCK???

- In nearly all urology and ED textbooks:
  - Ureteropelvic junction
  - Iliac vessels
  - Ureterovesical junction
- In actuality, proximal ureter and ureterovesical junction are most common!

URETERAL STONES

- REASONS FOR INTERVENTION
  - Fever/pyelonephritis – needs emergency stent
  - Renal insufficiency
    - Uncommon in healthy patient
    - Bilateral stones
  - Unremitting pain/colic
    - SWL or ureteroscopy appropriate
  - If patient can tolerate PO and pain is controlled, reasonable to give 2-4 weeks trial of passage w/ alpha blocker
FOLLOW-UP: WHEN AND WHY

- Stones left untreated in the ureter in the long term can lead to strictures and renal atrophy

F/u is imperative to ensure stone passage or appropriate treatment

IMAGING FOR PATIENTS WITH STONES

- CT (computerized tomography)
  - Gold standard at many institutions
  - Most sensitive and specific study for detection of urinary tract stones
  - May find non-GU or non-stone pathology
  - RADIATION AND COST ARE A CONCERN!!!!

6 mm left UVJ stone
IMAGING FOR PATIENTS WITH STONES

- Ultrasound + KUB

- US – high sensitivity for hydronephrosis (up to 95%)
  - Does not see ureter well

- KUB
  - 70-80% of calcium-based stones
  - ~15% uric acid stones

- DECREASED COST AND RADIATION DOSE!!!

URETERAL STENT

- Temporary stent passed alongside stone that is anchored in kidney and bladder to drain kidney

- Temporizing measure

- May cause urinary frequency, urgency, back pain

http://www.meddean.luc.edu/lumen/MedEd/urology/ushydro.htm
SHOCK WAVE LITHOTRIPSY

- External ultrasound used to break stones
- Ultrasound creates bubbles within urine which fracture stones
- TRULY minimally invasive
- Used for renal and ureteral stones ≤ 1 cm

50-70% success rates

- Highest success for:
  - Single stone
  - “soft stone”
  - Lower BMI

- Cannot be used:
  - Pregnancy
  - Coagulopathy
  - “blood thinners”
  - Active UTI
URETEROSCOPY

- Ureteroscope passed into penis (males) or urethra (females)
- Laser or other energy source used to fracture stone
- More invasive than SWL, but still reasonably non-invasive
- Used for renal and ureteral stones ≤ 1 cm

URETEROSCOPY

- Higher success than SWL (~90-95%)
- Can do in patients with higher BMI or on anti-coagulation
- Patients often require stent for several days for post-operative healing
PERCUTANEOUS NEPHROLITHOTOMY

- For largest stones – typically renal stones > 1.5-2.0 cm
- Used for branched (staghorn) stones

THANK YOU!!!!

- Thank you for this opportunity to present.
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