Canadian Undergraduate Urology Curriculum (CanUUC):

URINARY CALCULUS DISEASE

Objectives

1. List the signs/symptoms and differential diagnoses of an acute stone episode
2. Describe the imaging studies available to diagnose renal or ureteral calculi.
3. List the classes of medications effective for treating the pain of renal colic.
4. Outline the basic treatment options for renal and ureteral calculi
5. Describe the clinical scenarios requiring urgent decompression of a ureteral stone.
6. List the basic principles of stone formation and prevention.

Urinary Calculus Disease: Why care?

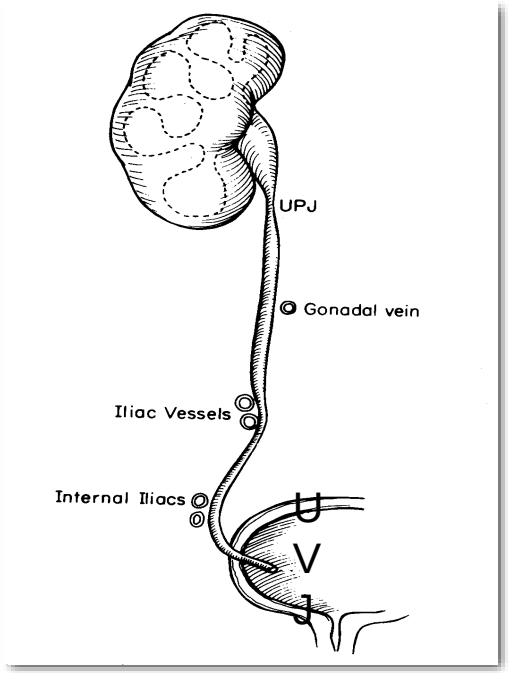
- **Lifetime prevalence**
  - Males - 6-12%
  - Females - 4-5%
- **Recurrence rates are 7-10% per year**
- **First presentation usually in young adults**
  - Age 20-40
- **Estimated $2 billion dollars spent on the diagnosis and management of urolithiasis in the US in 2001**

Urinary Calculus Disease: Signs and Symptoms

- **Colic nature of the pain**
  - Rapid onset
  - Unable to achieve comfortable position (writhing)
- **Radiates from flank to groin**
  - Testis/labia
- **Associated nausea/emesis**
  - May develop ileus
- **Hematuria**
  - Gross, microscopic (present in 90%; absence doesn't r/o)
- **Irritative LUTS**
  - May indicate stone near the UVJ/distal ureter
- **BEWARE OF FEVER**

Urinary Calculus Disease: Where do stones get stuck?

1. UPJ: Ureteropelvic Junction where the renal pelvis meets the ureter
2. Pelvic brim: at the level of the common iliac vessels
3. UVJ: Uretero-vesical junction where the ureter meets the bladder



Urinary Calculus Disease: Differential Diagnosis

- **Vascular:**
  - AAA
- **Bowel:**
  - Inflammatory bowel disease, appendicitis, diverticulitis
- **Gynecologic:**
  - PID, ruptured ovarian cyst, ectopic pregnancy
- **Neurologic/Musculoskeletal:**
  - Radicular pain, herpes zoster, muscle spasm/strain
- **Genito-urinary:**
  - Cystitis, pyelonephritis, torsion, UPJ obstruction

Urinary Calculus Disease: Investigations

AFTER CAREFUL History and Physical

Labs:

- Urinalysis (microscopy is gold standard to look for crystals)
- Consider Pregnancy Test (HCG) in females
- CBC&diff (Look for ↑WBC, creatinine (R/o renal failure)

Imaging:

- KUB (Kidney-Ureter-Pelvis) Plain Radiograph of abd/pelvis
- Non-contrast **Low-Dose** CT abdopelvis (NCCT)
- IVP - more or less historical or in remote settings
- Ultrasound - first line in pregnancy

Fulgham et al., J Urol, 2013

Urinary Calculus Disease: Urinalysis

- **90% will have at least microhematuria**
- **May have some pyuria**
  - May not indicate UTI
- **May have crystals**
  - Not specific for stone disease

Urinary Calculus Disease: Diagnosis - Imaging

- **KUB: First-line for initial and FU imaging**
  - 80-90% of stones are radio-opaque
  - Phleboliths (calcified pelvic vessels could be mistaken for ureteral stones)
    - » IVP (historic) : Can't use in patients with Iodine allergy or Renal Failure
  - Demonstrates stone location & degree of obstruction
  - Time consuming & contrast risk
- **CT (Non-contrast) LOW-DOSE protocol**
  - Quick, sensitive, GOLD STANDARD for renal colic
  - R/o concurrent intra-abdominal pathology

Fulgham et al., J Urol, 2013

Diagnosis: KUB

Advantages:

- 80-90% of stones are radio-opaque
- Minimal radiation

Disadvantages:

- No detection of concurrent pathology
- Bowel gas
- Easy to miss mid-ureteral stones over the sacrum

Diagnosis: Non-Contrast "Renal Colic" CT

Advantages:

- All stone types visible except indinivir
  - » SN - 97%; SP - 96%
- Rapid
- Readily available
- Does not require contrast
- Other pathology identified
- Information about stone and collecting system obtained

Fulgham et al., J Urol, 2013

Diagnosis:
Non-Contrast "Renal Colic" Low-Dose CT Abd/Pelvis

Disadvantages:

- Increased radiation dose compared with KUB
  - » Should always use Low-Dose protocols especially in thin (BMI <30) patients
- Cost
- No physiologic information such as obstruction
- Has supplanted the KUB
  - » KUB useful for following radio-opaque stones and determining suitability for Shockwave Lithotripsy (SWL)

Fulgham et al., J Urol, 2013

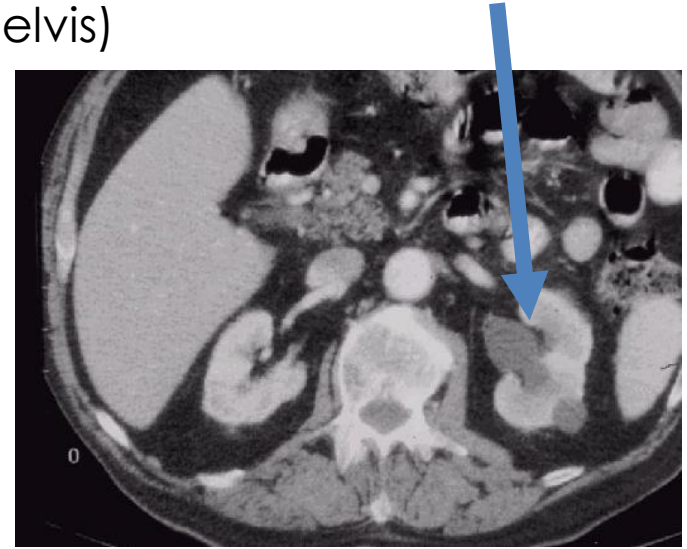
Diagnosis: Non-contrast CT (NCCT) What are you looking for?

- ❑ **Stone size** (height and width)
- ❑ **Stone density** (Stones >500HU are opaque on KUB)
- ❑ **Location**
  - Renal (Pelvis; upper, mid, or lower calyx)
  - Ureteral (UPJ, proximal, mid, distal, or UVJ)
- ❑ **Presence of hydronephrosis or hydroureter**
- ❑ **Evidence of stranding**
- ❑ **Gas in the collecting system**
  - Emphysematous (necrotizing) infection
  - Rare but important finding necessitating urgent broad spectrum antibiotics and drainage with NT

Diagnosis: Non-contrast CT

- Hydronephrosis

(Note the L renal pelvis is dilated when compared with R renal pelvis)

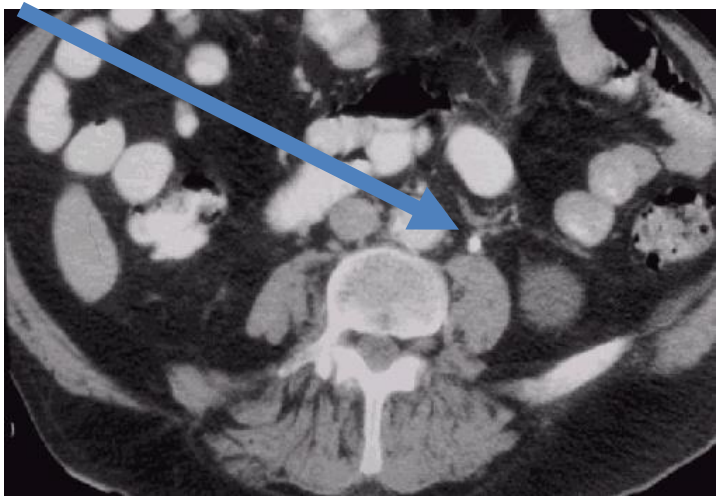


Non-contrast CT: Ureteral Calculus

- Dilated ureter above stone (hydroureter)

Ureteral Calculus: Non-contrast CT

- Stone visualization & location (i.e. L proximal ureter)
- All stones, except indinavir, are "opaque" on CT
- "Tissue ring" sign



Calculus Disease: Initial Management of Renal Colic

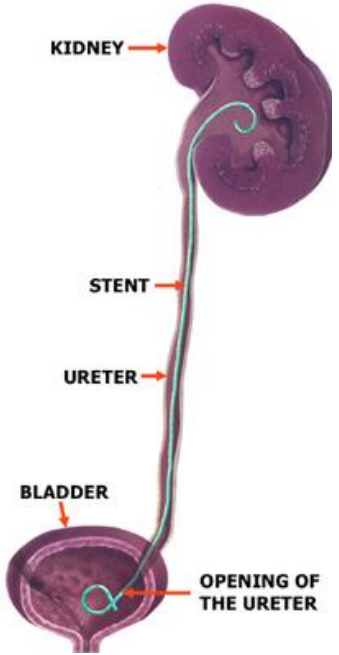
- **Pain control**
  - Narcotics
    - Oral/IM/IV
  - NSAIDS (renal function) (Avoid if planning SWL)
    - Oral/rectal/IV
  - Acetaminophen
  - Anti-emetics
- **IV hydration prn**
- **IF FEVER - CONSULT UROLOGY**
  - DISCUSS ANTIBIOTICS
- **Alpha-blockers as medical expulsive therapy (MET)**
  - Tamsulosin (Explain that these are off-label and associated with dizziness and retrograde ejaculation)

Calculus Disease: Initial Management Based on Size

- **<5mm (renal or ureteral)**
  - Discharge home with instructions to drink >2L of water/day
  - Tamsulosin for ureteral stones
  - 90% will pass spontaneously
  - Should follow-up with urology within 1-2 weeks
    - » Fear is silent obstruction (painless) with UPJ or proximal ureteral stones leading to irreversible renal loss
- **>5mm or signs of obstruction**
  - Consult urology
  - +/- tamsulosin

Urinary Calculus Disease: CONSULT UROLOGY URGENTLY IF:

- **Obstructing stone + FEVER/Infection**
- **Bilateral Ureteral Stones**
  - Renal failure
- **Solitary Kidney**
  - Impending renal failure
- **These require urgent decompression with ureteral (double J) stents or nephrostomy**



Urinary Calculi: Treatment

1. **Extracorporeal shock wave lithotripsy (SWL)**
    - Ureteral stones <1cm or renal stones <2cm
2. **Ureteroscopic laser lithotripsy (URS)**
    - Ureteral stones or SWL failures
3. **Percutaneous nephrolithotomy (PCNL)**
    - Large >2cm renal stones

Ordon et al., Can Urol Assoc J, 2015

Renal Calculi: Clinical Points

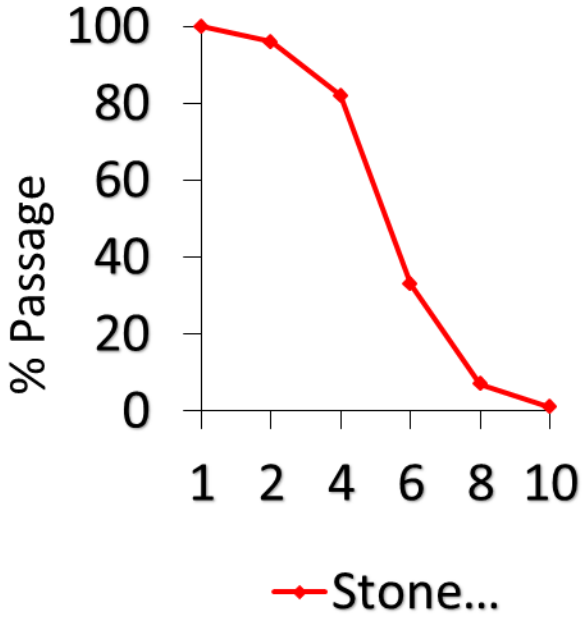
Spontaneous stone passage depends on:

1) Location: Proximal vs. distal (distal stones more likely to pass)
2) Size: ~90% of stones <5mm will pass
3) Time since onset: Most stones pass by ~40 days

Ordon et al., Can Urol Assoc J, 2015

Stone Size: Probability of Stone Passage

- **Probability of passage:**
  - <4mm- ~90%
  - 4-7mm- ~50%
  - >7mm- <10%



Ueno et al. Urol, 1977; Ordon et al., Can Urol Assoc J, 2015

Urinary Calculus Disease Treatment: Extra-corporal Shockwave Lithotripsy (SWL)

- Least invasive
- Conscious sedation
- Fragments stones that the patient then passes
- High patient satisfaction
- May require more time to become stone free
- Renal calculi <2cm or ureteral calculi <1cm

SWL: Absolute Contra-indications

- Pregnancy
- Bleeding Disorder/anticoagulation (NSAIDS pre-op)
- Febrile UTI
- Obstruction Distal to the stone being treated

SWL: Relative Contra-indications

- **Radiolucent stones due to difficulty in localizing. To localize these stones:**
  - Could use ultrasound
  - Could use retrograde pyelography or IVP
- **Pacemaker** (Need to use gated shockwaves; Pacemakers in the path of shockwaves could be damaged)
- **Calcified renal artery/AAA**
- **Severe orthopedic deformities**

Post SWL follow-up:

- Tamsulosin improves stone-free rates
- KUB in 2-4 weeks post-treatment
- May continue to pass fragments for several weeks
- Ultrasound to rule out silent obstruction

Fulgham et al., J Urol, 2013; Ordon et al., Can Urol Assoc J, 2015

SWL success depends on:

- **Stone Size (Better if <1cm)**
- **Stone Location (Better if renal pelvic)**
- **Stone Density/ Composition (Better if HU<1000)**
  - Hounsfield unit density on NCCT
- **Patient Habitus (Better if skin-to-stone distance <10cm)**
- **Worse if associated renal anomalies:**
  - UPJ Obstruction
  - Horseshoe kidney

Ordon et al., Can Urol Assoc J, 2015

Complications of SWL

- **Hematuria**
- **Hematochezia**
- **Ureteral obstruction - 5-30%**
  - Depends on size of initial stone
  - "steinstrasse" (stone fragments obstructing ureter)
  - Intervention as per other ureteral stones
- **Sepsis - 1%**
- **Perinephric Hematoma - <1%**
- **Hypertension/DM- no convincing evidence that SWL leads to long term HTN or DM**

When do we not use SWL?

- **Stone Burden**
  - >2cm in largest diameter or multiple stones
- **Stone composition**
  - Particularly cystine or brushite stones
- **Patient needs to be stone-free such as pilots**
  - Or stone-free faster
- **Patient habitus (skin-to-stone distance >10cm)**
- **Failed SWL**
  - 2nd treatment reasonable
  - Diminishing returns of 3 or more treatments

Ordon et al., Can Urol Assoc J, 2015

URS for Ureteral Stones

Advantages:

- Near 100% stone free rate
- Low retreatment rates
- Treatment available in most centres
  - SWL tends to be in regional centres only

Disadvantages:

- General anesthesia is usually required
- Ureteral stent (DJ) may be left
  - Stent symptoms are bothersome to patients
- Lower patient satisfaction

Typically for ureteral calculi and SWL failures

Ordon et al., Can Urol Assoc J, 2015

Ureteroscopic Equipment:

Scopes are either:

- Semi-rigid
- Flexible

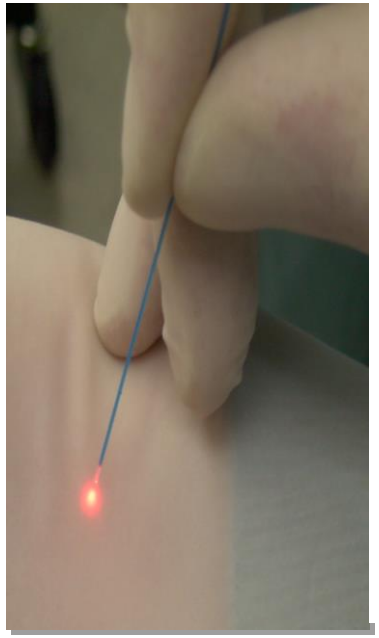
Stone Fragmentation:

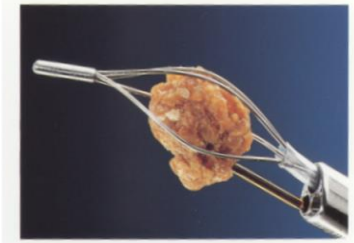
- Holmium:YAG laser

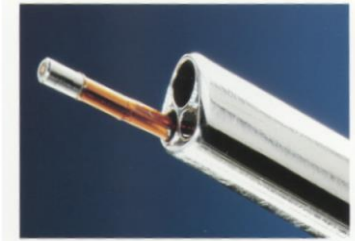
Stone Retrieval:

- Baskets
- Graspers

One of the best innovations in urology over the last 2 decades







Urinary Calculus Disease: Percutaneous Nephrolithotripsy

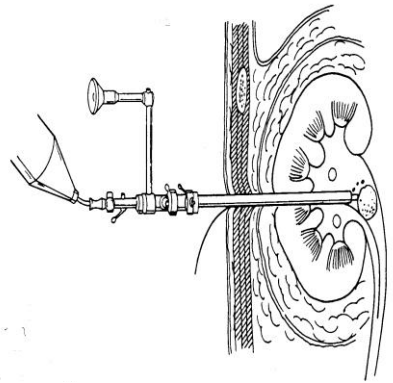
Typically for large (>2cm) renal calculi

Advantages:

- Ability to remove large or multiple stone burden with high success rate (>95%)

Disadvantages:

- General anesthesia
- More invasive than URS
- Risk of bleeding <5% require transfusion
- Injury to surrounding organs
- Risk of hydropneumothorax



Percutaneous Nephrolithotripsy: Complications

- **Sepsis or SIRS**
- **Bleeding requiring transfusion or selective angioembolization.**
- **Perforation of the renal pelvis**
- **Stricture**
  - UPJ or infundibulum
- **Residual stone fragments**
- **Hemothorax/pleural effusion (<10%)**
- **Adjacent organ injury (colon perforation)**

Stone Prevention

Stone Prevention: Basic Work-Up for ALL PATIENTS

- **Urinalysis and culture:**
  - Urea splitting organisms (Proteus, Pseudomonas, Klebsiella, mycoplasma, Serratia, Staph Aureus)
  - Acidic urine - uric acid or cystine stones
  - Alkaline urine – calcium phosphate stone or struvite stones
- **Serum electrolytes (Na, K, Cl, HCO_3), urea, creatinine, uric acid and calcium**
- **If elevated or normal high serum calcium then obtain PTH to rule out Primary Hyperparathyroidism**
- **Send stone for analysis**

Dion et al., Can Urol Assoc J, 2016

Stone Prevention: Detailed Metabolic Work-Up Indications

- Children (<18 years of age)
- Bilateral, recurrent or multiple stones
- Non-calcium stones (e.g., uric acid, cystine)
- Pure calcium phosphate stones
- Complications from stones (AKI, sepsis, or admission)
- Any stone requiring percutaneous nephrolithotomy
- Solitary kidneys (anatomical or functional)
- Patients with renal insufficiency
- Systemic disease (gout, osteoporosis, bowel disorders, hyperparathyroidism, renal tubular acidosis,etc.)
- High-risk occupations (e.g., pilots, firemen)
- Interested first time stone formers

Dion et al., Can Urol Assoc J, 2016

Stone Prevention: Detailed Metabolic Work-Up

In addition to the Basic metabolic work-up, it includes:

- Two 24-hour urine collections:
- Volume, creatinine, calcium, sodium, potassium, oxalate, citrate, uric acid, magnesium
- +/-cystine if the stone analysis is cystine

Dion et al., Can Urol Assoc J, 2016

Stone Prevention: General Advice

Increase Hydration to 2-3L per day to achieve daily urine output of 2.5L

Diet:

- Maintain normal calcium intake (1000-1200mg with meals)
  - Used to advice low calcium diets – Proven to be false
- Minimize foods high in oxalate (Spinach, peanut, rhubarb)
- Minimize salt (<2300mg/d) and animal protein
- Increase fiber, vegetables and citrus-rich fruits

Consider urinary alkalinization:

- Mainly for uric acid and cystine stones
- Potassium citrate - preferred
- Sodium citrate or bicarbonate - alternative

Dion et al., Can Urol Assoc J, 2016

Stone Prevention: Calcium Stones (80%)

- **Most stones are calcium oxalate**
- **Some are calcium phosphate or mixed**
- **Etiology**
  - Hypercalciuria
    - » Increased intestinal absorption
    - » Bone resorption (↑PTH)
    - » Renal leak
  - 25% also have hyperuricosuria
  - Hyperoxaluria
    - » Usually increased intestinal absorption – small bowel resection/IBD
    - » Ingestion of oxalate-rich foods
  - Hypocitraturia

Dion et al., Can Urol Assoc J, 2016

Stone Prevention: Prevention of Calcium Stones

- **Hydration - 2-3L of urine per day**
- **Normal dietary calcium intake (1000-1200mg/d)**
- **Dietary limitations:**
  - Salt - potentiates hypercalciuria
  - Oxalates – Tea/chocolate/Spinach/Rhubarb
  - Animal protein
- **Consider Thiazide for hypercalciuria**
- **Consider potassium citrate for hypocitraturia**

Dion et al., Can Urol Assoc J, 2016

Stone Prevention: Struvite Stones (5-10%)

- **Triple phosphate**
  - Calcium Magnesium, ammonium phosphate
- **Alkaline urine pH due to urea splitting organisms**
  - Proteus, Pseudomonas, Klebsiella, Mycoplasma, Serratia, Staph Aureus
  - NOT E COLI
- **Must clear all stone material and infection**
  - SWL often not useful
- **May form staghorn stones quickly**

Dion et al., Can Urol Assoc J, 2016

Stone Prevention: Uric Acid Stones (10%)

- **Radiolucent - not visible on KUB**
- **Occur in patients with low urine volume and acidic urine (pH<6.0)**
  - Purine-rich diets
  - High cell turnover - cancer treatment

Prevention:

- Hydration
- Decrease protein intake
- Alkalinize urine
  - Potassium citrate of sodium bicarbonate

Dion et al., Can Urol Assoc J, 2016

Stone Prevention: Cystine Stones

- **Usually first detected in children**
  - Often positive family history
- **AR defect in absorption of dibasic amino acids**
  - COLA (cystine, ornithine, lysine, arginine)
  - Only cystine is insoluble
- **Rapid formation of staghorn stones**
- **Must remove all stone material aggressively**
  - SWL has limited application

Prevention:

- Hydration (Need to produce >3L of urine per day)
- Low salt and animal protein
- Alkalinize urine (cystine is soluble in alkaline urine)
- penicillamine, thiola (disulfide bond binders)

Dion et al., Can Urol Assoc J, 2016

Take Home Points: Urinary Calculi

- KUB is a useful initial investigation
- Low-Dose non-contrast CT is the diagnostic gold standard
- Fever with an obstructing ureteral stone requires emergent intervention (decompression – stent/nephrostomy)
- Obstructing stones in a solitary kidney require emergent attention

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