



Urolithiasis

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Epidemiology

Urolithyasis is a common disease that estimated to produce medical cost of 2.1 billion dollars per year in USA

- 12% lifetime incidence
- Men affected 3 times as often as women
- Peak incidence rises at 35-45 of age .

Prevalence **higher** in desert, and tropical areas and during the summer

Stone Types



Percent
of all stones

Etiologic Factors

Calcium Oxalate/Struvite	75%	Underlying Metabolic disorder... (e.g., idiopathic hypercalcuria, hyperoxaluria)
Calcium Phosphate	15%	No metabolic disorder identified in 25% Renal Infection... (Proteus, Klebsiella)
Uric Acid	6%	50% idiopathic; Hyperuricemia, hyperuricosuria
Cystine	2%	Renal tubular defect

Rare stones types

1. Ammonium acid urate,
2. Triamterene,
3. Indinivir

Causes of stone formation



Hereditary disorders :

familial renal tubular acidosis (RTA),
cystinuria,
xanthinuria,
glucose 6-phosphate deficiency,
oxaluria,

Dietary excesses :

vitamin C ingestion,
oxalate,
purines,
Calcium

Sedentary lifestyle or immobilization

Thiazide-induced

UTIs with urea-splitting organisms

Myeloproliferative disorders

Gastrointestinal disorders (inflammatory
bowel disease)

Dehydration

Hypercalcemic disorders :

hyperparathyroidism,
sarcoidosis,
leprosy,
hyperthyroidism,
secondary to glucocorticoids,
malignancy,
tuberculosis,
pheochromocytoma

Diagnostic Classification of Nephrolithiasis

CONDITION	METABOLIC/ENVIRONMENTAL DEFECT	PREVALENCE (%)
Absorptive hypercalciuria		20-40
Type I	Increased gastrointestinal calcium absorption	
Type II	Increased gastrointestinal calcium absorption	
Renal phosphate leak	Impaired renal phosphorus absorption	
Renal hypercalciuria	Impaired renal calcium reabsorption	5-8
Resorptive hypercalciuria	Primary hyperparathyroidism	3-5
Hyperuricosuric calcium nephrolithiasis	Dietary purine excess, uric acid overproduction	10-40
Hypocitraturic calcium nephrolithiasis		10-50
Isolated	Idiopathic	
Chronic diarrheal syndrome	Gastrointestinal alkali loss	
Distal renal tubular acidosis	Impaired renal acid excretion	
Thiazide-induced	Hypokalemia	
Hyperoxaluric calcium nephrolithiasis		2-15
Primary hyperoxaluria	Oxalate overproduction	
Dietary hyperoxaluria	Increased dietary oxalate	
Enteric hyperoxaluria	Increased intestinal oxalate absorption	
Hypomagnesiuric calcium nephrolithiasis	Decreased intestinal magnesium absorption	5-10
Gouty diathesis	Low urinary pH	15-30
Cystinuria	Impaired renal cystine reabsorption	<1
Infection stones	Infection with urease-producing bacteria	1-5
Low urine volume	Inadequate fluid intake	10-50
Miscellaneous or no abnormality	NA	<3

Hypercalciuria

Definition

4 mg/kg body wt/24-hr,
> 300 mg/24-hr for male,
> 275 mg/24-hr for female

Type

Absorptive (I and II): Normal serum Ca^{2+} , low PTH; **type II (diet dependent)**, normal fasting urine Ca^{2+}

Renal leak: Normal serum $\text{Ca}^{2+/-}$, high PTH, increased fasting urine Ca^{2+}

Resorptive: High serum Ca^{2+} , high PTH, high fasting urine Ca^{2+}

Hypercalciuria cont.

Diff type I and II : low Ca^{2+} , oxalate, Na^+ diet for 1 wk, check 24-hr urine;

- if urine $\text{Ca}^{2+} > 200$ **type I**, if < 200 **type II**

Diff type II from renal leak: 2-hr urine for Ca^{2+} after 14-16 hr, overnight fast: $> 30 \text{ mg } \text{Ca}^{2+}$ is renal leak

Hyperuricosuria

Definition

> 600-700 mg/24-hr urine

70% dietary, 30% overproduction.

hyperuricosuria may initiate calcium oxalate stone formation.

Acidic urine ($\text{pH} < 5.5$) $\pm$ hyperuricosuria.

Overproduction may be due to myeloproliferative dz, glycogen storage dz, malignancy, diarrhea

Hyperoxaluria

Definition

> 40-50 mg/24-hr urine

Causes: overindulgence, endogenous production, primary hyperoxaluria, inflammatory bowel dz

Diffdx

45-60 mg/d: dietary

45-400 mg/d: endogenous

80-400 mg/d: inflammatory bowel dz

Cystinuria

Definition : > 400 mg/24-hr urine

Cystine solubility is pH dependent . Increased solubility with pH > 7.5

Prevention

- **Alkalinize urine** to pH 7.5 with **potassium citrate** 30-60 mEq/d in divided doses;
- **D-penicillamine** 2 gm in 4 divided doses, start at 250 mg/d, increase gradually, or **tiopronin** 800 mg/d in 3 divided doses on empty stomach.

Risk factors :

Urine becomes supersaturated...

1. Decreased urine volume
2. Abnormal urine pH
3. Absence of inhibitors
4. Infection

Why stones form...

1. Decreased urine volume...

Urine concentrates, supersaturates & crystals precipitate.

2. Urine pH affects solubility...

Promotes precipitation of:

Acidic urine: Uric acid, Cystine, Ca
Oxalate

Alkaline urine: Ca phosphate, struvite

Why stones form...

3. Absence of inhibitors

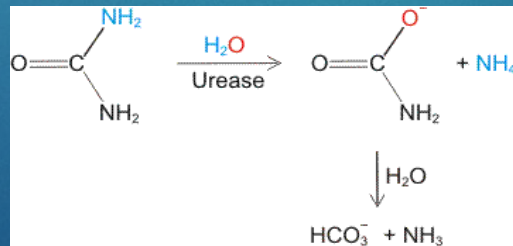
Citrate, Mg, glycosaminoglycans and Tamm Horsfall proteins, tend to inhibit stone formation

4. Infection:

Urea-splitting organisms (Proteus, Klebsiella) generate ammonia and alkalize urine



Proteus



Urease



Staghorn calculi (struvite)

Pathophysiology

Key event is **supersaturation** in the urine followed by **crystallization**

Once crystallization occurs, **aggregation** and **retention** must occur for a **calculus** to form.

Structural kidney disease

Medullary Sponge Kidney

Polycystic Kidney Disease



Horseshoe Kidney

Presentation...

Renal colic:

- Acute onset of sharp, spasmodic flank pain
- Episodes of severe pain last 20 – 60 minutes
- Location of pain depends on location of stone

Mechanism for pain:

- Stone lodges in ureter
- Ureteral spasm and hyperperistalsis
- Distention of renal capsule cause pain

Stones are found most commonly at...

- The ureteropelvic junction
- The iliac vessels
- The ureterovesical junction

Presentation...

Hematuria (microscopic or gross):

- 90% of patients have haematuria on first day of pain
- only 65% will have haematuria on days 3 and 4 ^(Kobayashi)

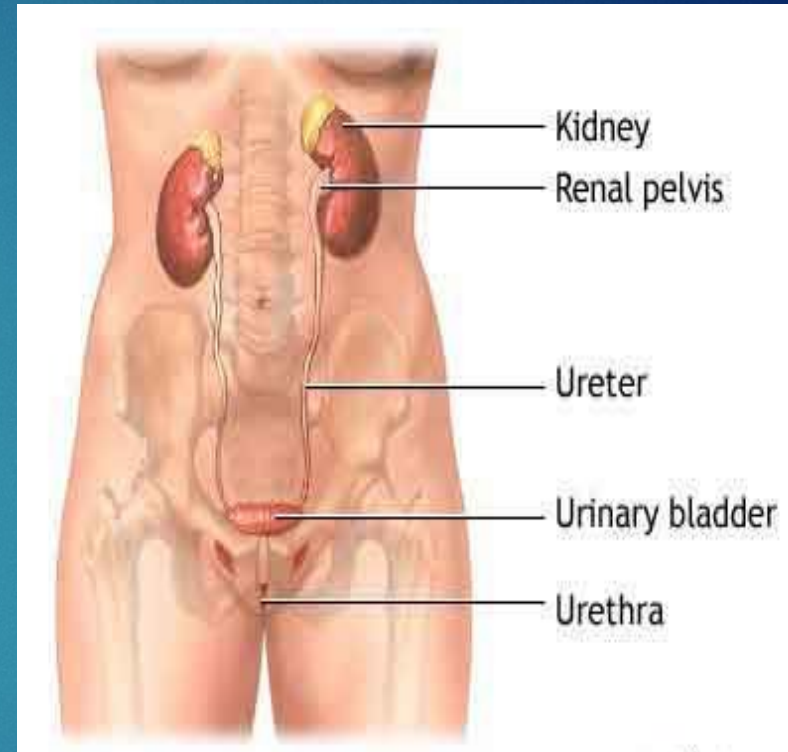
- Sometimes nausea and vomiting.
- May also see signs and symptoms secondary to complications

Clinical Manifestations

Obstructing calculi in the upper urinary tract cause an extreme crescendo like pain in the flank that generally radiates laterally around the abdomen to the corresponding groin and testicles in males and labia major in females.

Obstructing stone of the midureter, the pain tends to radiate to the lateral flank and abdominal region.

Obstruction in the distal ureter, the patient exhibits symptoms of bladder irritation (frequency and urgency or genital pain).



Presentation...

Staghorn Coral



Staghorn Calculus



Staghorn Fern



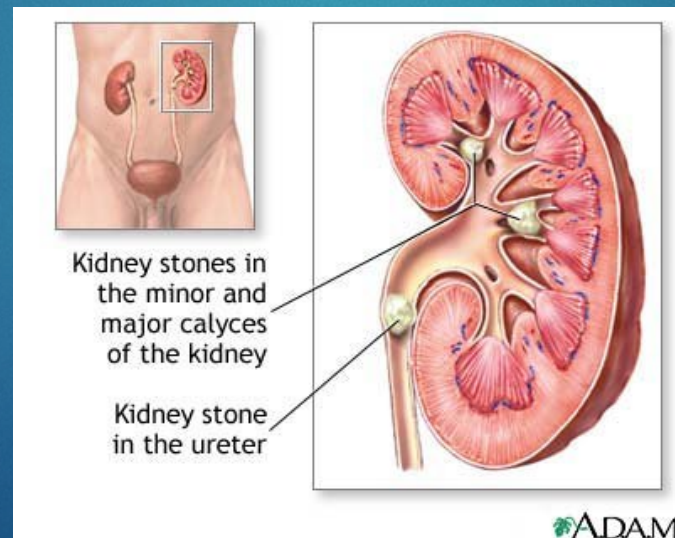
Staghorn caluli are **typically asymptomatic**
(unless there is obstruction or infection)

Complications...

A stone can lodge in the ureter, obstruct urine flow and dilate the proximal collecting system.

Elevated hydrostatic pressure in the collecting system can have detrimental effects on kidney function...

Infection
Pyelonephritis
Perinephric abscess
Urosepsis



Hydroureter
Hydronephrosis
Urine extravasation
Renal impairment

Diagnosis...

Lab. investigations

Images

- US
- KUB
- IVP
- CTU
- MRU



Lab investigations

Urine R/M

Renal function test

+/-

CBC

Metabolic work up

Indications for a Metabolic Stone Evaluation

Recurrent stone formers

Strong family history of stones

Intestinal disease (particularly chronic diarrhea)

Pathologic skeletal fractures

Osteoporosis

History of urinary tract infection with calculi

Personal history of gout

Infirm health (unable to tolerate repeat stone episodes)

Solitary kidney

Anatomic abnormalities

Renal insufficiency

Stones composed of cystine, uric acid, struvite

Metabolic work up,

24 hour urine

Ca
PO4
uric acid
Oxalate
Citrate
Na
pH

Blood test

RFT
Ca
PTH
Uric acid

Spot urine

UA
Urine sediment
Urine culture
Stone fragment
analysis

Images ,



Ultrasonography (US)...

First choice for diagnosis of urolithiasis in...

1. pregnant patients
2. children

Sonographic scan shows dilated intrarenal collecting system, consistent with obstructive urolithiasis.

US...

Disadvantages

1. Urinary tract dilation can take hours to develop, so the diagnosis of obstructive uropathy may be missed at the initial evaluation.
2. May miss small stones and stones in ureters
3. Patients need to be hydrated before exam
4. Stone size cannot be accurately measured

ureteral stone (arrow)
hydroureter (arrowheads)

Plain Film Radiography...



KUB will detect:
calcium stones
struvite
cystine stones

KUB will miss:
uric acid stones
small stones
stones obscured by bones
And gases

Radiograph of left kidney shows
a large stone (arrow) (Susah).

IVP

Urogram shows dilatation of left ureter and collecting system caused by calcific distal ureteral stone (arrow). (Sudha)

An abnormal IVU study showing obstructed, dilated left ureter and collecting system (Sudha)

NCCT,

Most commonly, the stone can be seen directly as an opacity within the urinary tract.

Impacted calculus at
ureterovesical junction

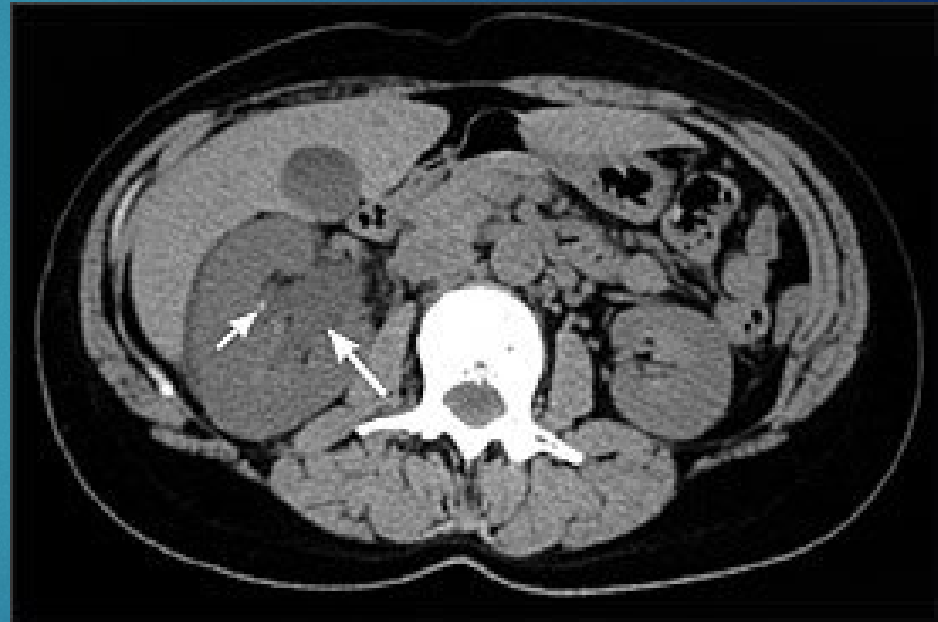
Stone in left ureter

(Catalano)

Hydroureter

Dilated renal pelvis (arrowhead) with minimal surrounding fat-tissue stranding

Hydronephrosis



Hydronephrosis in right kidney (long arrow) and tiny right renal calculus (short arrow). Left kidney is normal.

Magnetic Resonance Urography (MRU)

Limited role in evaluation of urinary tract stones.

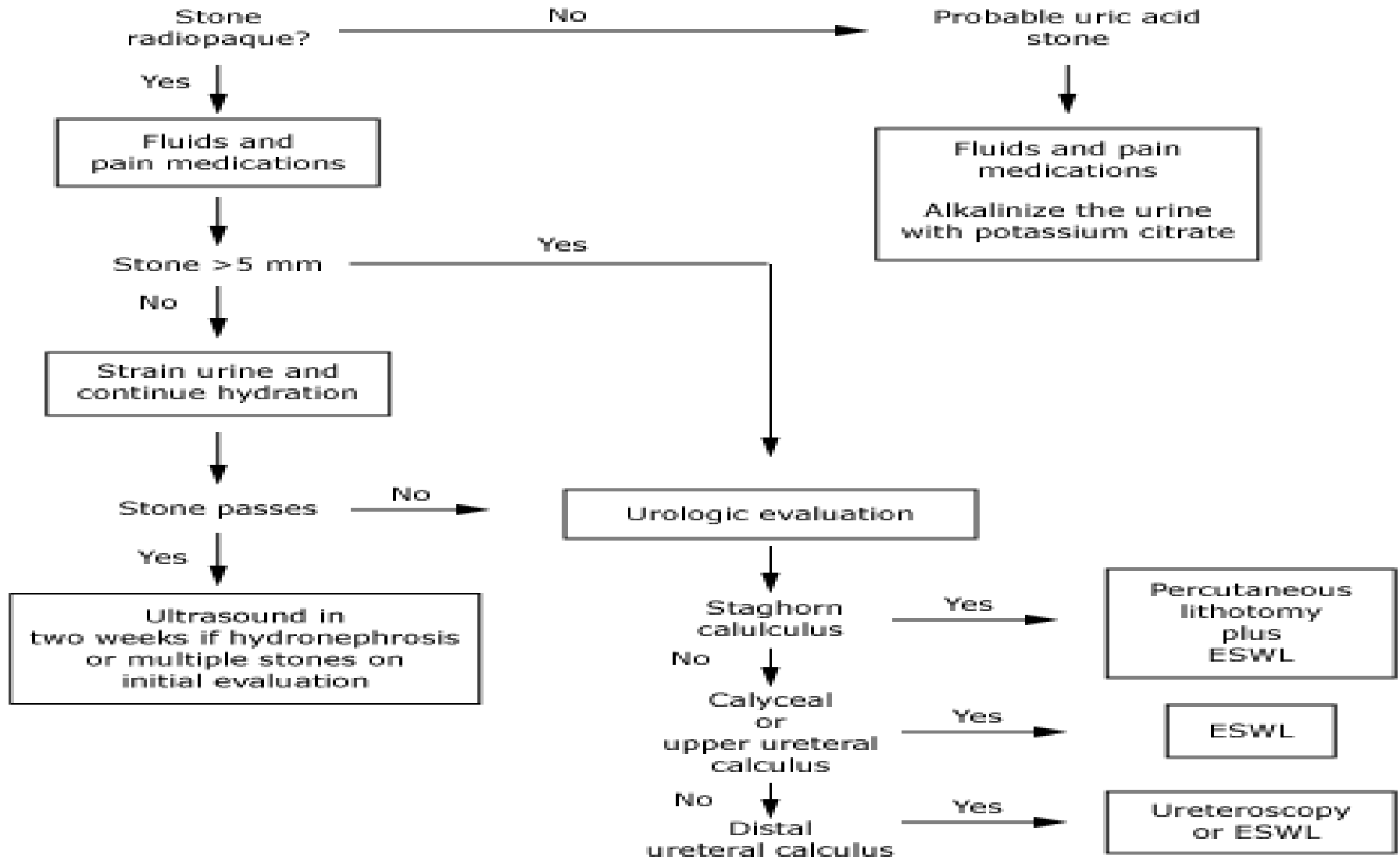
Dilatation of left ureter and collecting system (both images)

TREATMENT



Conservative
Surgical

Treatment...



(Curhan)

Conservative

Hydration
(IV or PO)

&

Analgesia
(NSAIDS & Opioids)

Stones < 5 mm are likely to pass spontaneously

Stones > 10 mm are very unlikely to pass spontaneously

Also, distal stones are more likely to pass spontaneously

Treatment...



Most patients will likely benefit from increased fluid intake (> 2 L/day)

Indications for admission to the hospital:

Intractable pain

Infection(fever)

Obstructing stone in single kidney

Bilateral obstructing ureteric stones

Renal impairment

Surgical options

Manage the obstruction :

- Ureteral stent insertion
- Percutaneous nephrostomy

Definitive management:

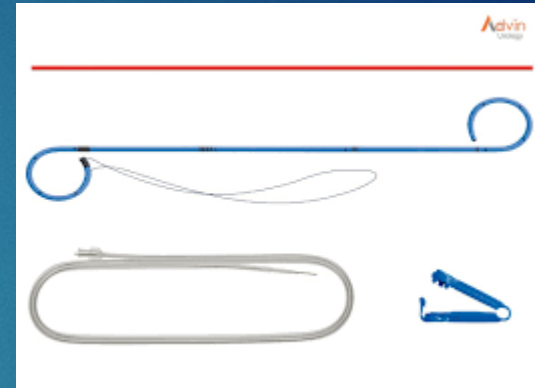
ESWL

Ureteroscopy

PCNL

Open, laparoscopic and robotic
pyelo-lithotomy, ureterolithotomy,
cystolithotomy

Open anatomic nephrolithotomy



Treatment...

Calcium stones:

1. Thiazide diuretic
2. Low sodium diet for hypercalciuria
3. DO NOT decrease Ca intake

Struvite stones (Magnesium ammonium phosphate):

- Stone removal with percutaneous nephrolithotomy
2. Antibiotics to treat urease-producing bacteria

Uric acid stones:

1. Urine alkalinization (potassium citrate);
2. Allopurinol

Cystine stones:

1. High fluid intake
2. Urinary alkalinization (potassium citrate)



THANKS

