IN THE NAME OF GOD

Renal Stones

Uric acid & Struvite

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Outlines

- INTRODUCTION
- PATHOGENESIS
- CLINICAL MANIFESTATIONS
- DIAGNOSIS
- TREATMENT
- OUTCOMES

INTRODUCTION

Uric acid stones account for **5 to 10 percent** of urinary tract stones in the United States and Europe however, they comprise 40 percent or more of stones in areas with hot, arid climates.

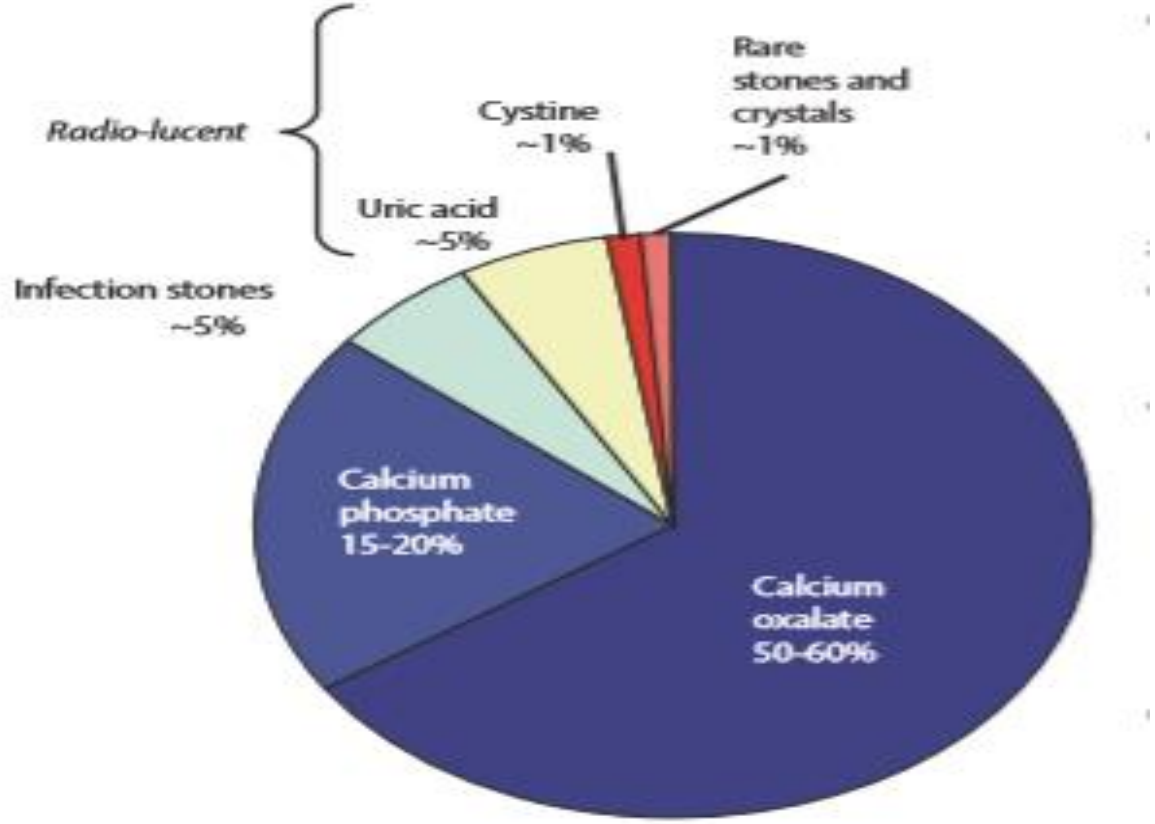


Table 55.5 Suggested referral criteria for metabolic screening

Suggested referral criteria for metabolic screening
Any of the following:
1. First presentation at age <25
2. Bilateral or multiple stones (any age)
3. First stone episode with strong family history (any age)
4. Associated impaired renal function (eGFR <60 – Any age)
5. Any non-calcium stone (any age)
6. Single functioning kidney or renal transplant
7. Difficult surgical approach/high anaesthetic risk
8. Anatomical abnormality posing a high risk, e.g. renal malformation, ileostomy, some urinary diversion procedures
9. Coexisting severe bone disease
10. Potential live kidney donor with documented or incidental stone, risk factors, or strong family history

Uric acid Stones

PATHOGENESIS

The two major factors that promote uric acid precipitation:

- High urine uric acid concentration
- Acid urine Ph

❖ **converting the relatively soluble urate salt into insoluble uric acid:**

$H^+ + Urate^- \leftrightarrow$ Uric acid

55.3.1 Metabolic Risk Factors

A recent survey of young stone formers found that 64% had a single metabolic risk factor, with 27% having more than one [14]. Below is a breakdown of the commonly found metabolic risk factors present in a typical cohort of stone formers:

Hypercalciuria	**50%**
Hypocitraturia	**25%**
Hypomagnesuria	**10%**
Hyperuricosuria	**3%**
Hyperoxaluria	**1%**

PREDISPOSING CLINICAL CONDITIONS

- Gout
- Increased fractional excretion of uric acid
- Uric acid overproduction
- Chronic diarrhea
- Diabetes mellitus
- metabolic syndrome

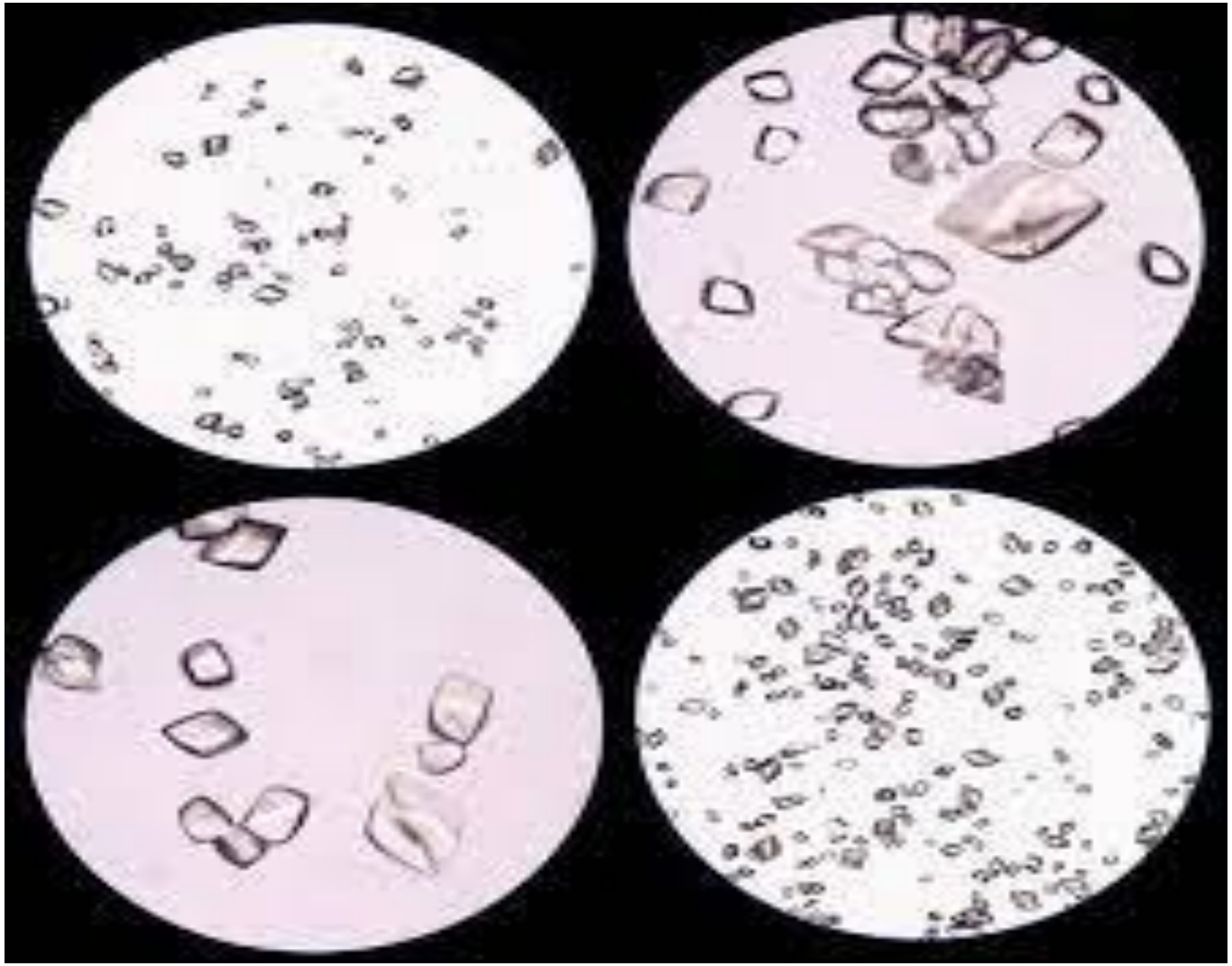
DIAGNOSIS

- Usually present with the acute onset of flank pain.
- **Non-contrast-enhanced CT** scan is the preferred radiologic test to establish the presence of a stone, but may be negative if a stone has passed.
- **Plain radiography is not helpful**, since uric acid stones are radiolucent.
- Frequent passage of "sand" or "gravel" in the urine.
- There is increasing evidence suggesting that **dual-energy CT scan or helical CT can** distinguish among different types of stones, including differentiating uric acid from calcium stones.

DIAGNOSIS…

- The type of stone is best determined by chemical analysis of a stone.
- The variables that should be measured in the 24-hour urine collections are **total volume, urea ,calcium, oxalate, citrate, uric acid, sodium, potassium, phosphorus, pH, and creatinine ,Cystine and magnesium.**
- **24-hour urine collection**, which is a **standard test** in the evaluation of nephrolithiasis, does not typically reveal hyperuricosuria.
- Most commercial laboratories offer testing of **24-hour urine sam**ples to evaluate **kidney stone risk**.
- laboratories will calculate the urinary supersaturation of uric acid, which is a helpful parameter to **follow during treatment** since it integrates **urine volume, uric acid excretion, and pH.**

uric acid crystals



TREATMENT

The options to prevent recurrent uric acid nephrolithiasis :

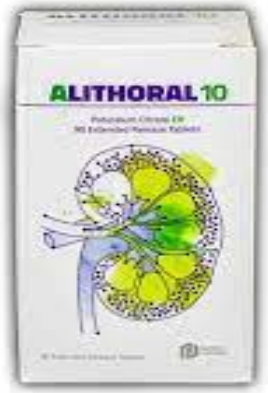
- Alkalinization of the urine.
- Increased fluid intake.
- Reduction of uric acid production with reduced purine intake and xanthine oxidase inhibitors.

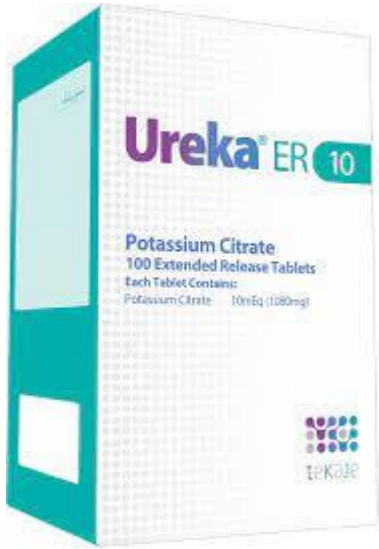
- Because alkalinization of the urine with medical therapy can lead to dissolution of pure uric acid stones, more **invasive procedures** (such as ESWL) are **usually not required**.

Urinary alkalinization

- Alkalinization therapy should target a urine **pH between 6.5 and 7**.
- **Achieving a urine pH higher than 7** may **increase the risk of calcium phosphate stone formation**.
- An alkaline urine pH **may not need** to be maintained **at all times** since raising the urine pH to **at least 6.5 once per day or every other day** may prevent uric acid stone formation .
- Either **potassium bicarbonate or potassium citrate** , with the **typical dose being 40 to 80 mEq/day** can dissolve preexisting pure uric acid stones and prevent the formation of new stones.
- **Potassium salts** is preferable since the **sodium load with sodium citrate or sodium bicarbonate may increase calcium excretion and promote the formation of calcium stones in some patients.**

Potassium Citrate





Increased fluid intake

Patients should be encouraged to drink enough fluids to achieve **a 24-hour urine volume of at least two liters**

TREATMENT…

The indications for xanthine oxidase inhibitors:

- Uric acid stones are recurrent despite alkalinization.
- Alkalinization cannot be used.
- Presence or absence of gout.

Recurrent uric acid stones

- Recurrent uric acid stone formation despite urinary alkalinization and increased hydration usually occurs in patients with high urinary uric acid excretion (**exceeding 1000 mg/day**).

- Xanthine oxidase inhibitor therapy is warranted in recurrent uric acid stone formers even if urinary uric acid excretion is in the reference range.

Patients with gout

- Patients with **recurrent or tophaceous gouty arthritis** should be treated with a xanthine oxidase inhibitor for long-term control of gouty manifestations; **the primary indication in such patients is gout and not necessarily the prevention of kidney stones .**

- In a patient with a history of uric acid stones and gout **but ≤1 flare of gouty arthritis per year**, there **may be no specific indication for xanthine oxidase inhibitor therapy.**

- Urinary alkalinization and increased hydration are the initial treatment option in such patients.

Struvite stones

Struvite stones may grow rapidly over a period of **weeks to months** and, if not adequately treated, can develop into a **staghorn or branched calculus** that fills the entire **intrarenal collecting system**.

PATHOGENESIS

- Struvite stones are composed of **magnesium ammonium phosphate** & **calcium carbonate-apatite** .

- Struvite stone formation occurs only when **ammonia production is increased** and the urine pH is elevated, which decreases the solubility of phosphate.

- The only situation in which this occurs in humans is with an upper urinary tract infection with a urease-producing organism, such as *Proteus* or *Klebsiella*.

PATHOGENESIS…

- In comparison to those patients with pure struvite stones, **many men and some women have mixed calcium oxalate and struvite stones**.

primary event is calcium oxalate stone formation, with secondary upper UTI and struvite deposition.

- Patients with **pure struvite stones** may also benefit from a metabolic evaluation in addition to benefiting from a determination of the cause of the UTI .

EPIDEMIOLOGY

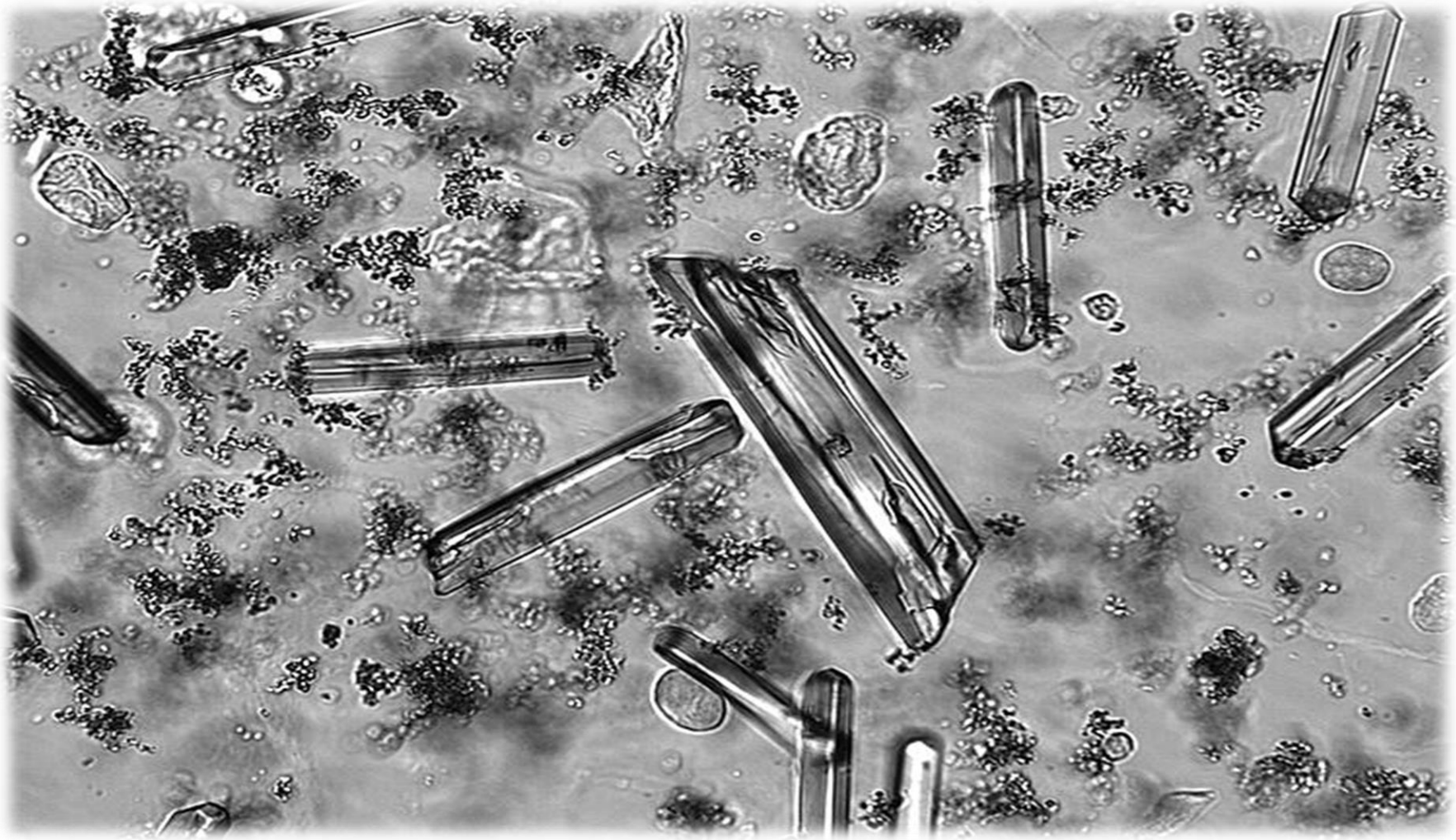
- **Women** are more likely to form **pure struvite stones** (3:1) because females are more likely to develop an upper UTI .

- Those with a **neurogenic bladder or a urinary diversion**, also may form pure struvite stones.

CLINICAL MANIFESTATIONS

- Symptoms directly attributable to struvite stones are uncommon.
- More often, patients will present with symptoms of UTI, mild flank pain, hematuria, often with multiple magnesium ammonium phosphate crystals in the urine sediment.
- A persistently infected stone often leads to focal areas of parenchymal scarring with loss of cortex (chronic pyelonephritis).
- Passage of a struvite stone is rare.
- When passed and collected or removed surgically, chemical analysis of these stones may falsely report the absence of struvite.

Magnesium Ammonium Phosphate Crystals



Management

- If left untreated, this can lead to deterioration of kidney function and ESRD.
- Since the stones often remain infected, there is a risk of developing sepsis .
- **Most patients require definitive surgical treatment**.
- There are several alternative surgical treatments for staghorn calculi.

Limitations of the data

- Data from randomized controlled studies comparing treatment options are very limited.

- There is no uniform system of categorizing staghorn calculi, and no widely accepted system of reporting the size of staghorn calculi.

- The indications for hospitalization may vary in different countries.

TREATMENT OPTIONS

- Medical therapy alone
- Open surgery
- Laparoscopic surgery
- Percutaneous nephrolithotomy (PNL)
- Shock-wave lithotripsy (SWL)
- Combination of PNL and SWL
- Combination of PNL and ureteroscopy

❖ Most commonly **PNL**, is **usually required** to treat struvite stones.

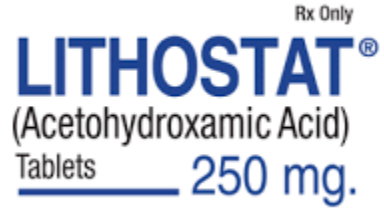
❖ Medical therapy alone is **not preferred** except in patients who are too **ill to tolerate, or who refuse stone removal.**

Medical therapy alone

- ✓ The medical treatment of struvite stones is rarely successful.
- ✓ Bacteria live within interstices of the stone where antimicrobial agents may not penetrate, and create a persistently alkaline local environment promoting stone growth.
- ✓ Chronic administration of a culture-specific antimicrobial agent can sometimes prevent further stone growth and should be initiated.
- ✓ Dietary phosphorus reduction and administration of urease inhibitors such as **acetohydroxamic acid** .
- ✓ **20 to 60 % of patients receiving AHA experience significant side effects such as:**palpitations, edema, nausea, vomiting, diarrhea, headache, loss of taste, hallucinations, rash, abdominal discomfort, anemia, and reticulocytosis (**all reversible**).

Medical therapy alone …

Routine surveillance every three to four months to monitor stone growth is mandatory for patients on medical therapy alone.



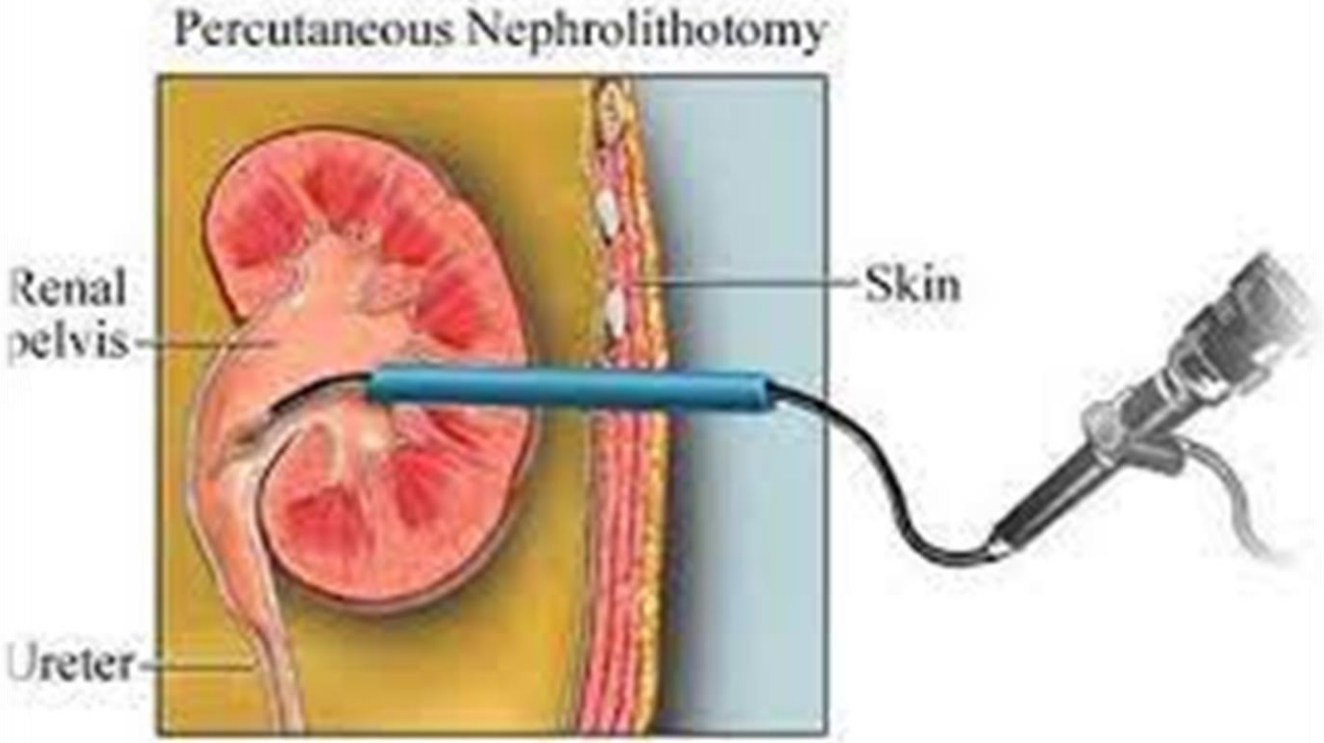
Percutaneous nephrolithotomy

The following are some advantages to PNL:

- If the stone can be accessed, it can almost always be removed.
- Direct inspection of the collecting system allows identification and removal of small fragments.
- Repeated inspections are possible because the tract can be kept open indefinitely.
- The process is relatively rapid, with success or failure being obvious immediately.

- **Hospitalization is usually from one to three days, with most patients returning to light activity after one week.**

Percutaneous nephrolithotomy



Shock-wave lithotripsy

➢ **Several reasons for the popularity of SWL:**

its **noninvasive** nature has much appeal; and the technique is widely available.
However, it often requires general or regional anesthesia.

➢ **Some disadvantages :**

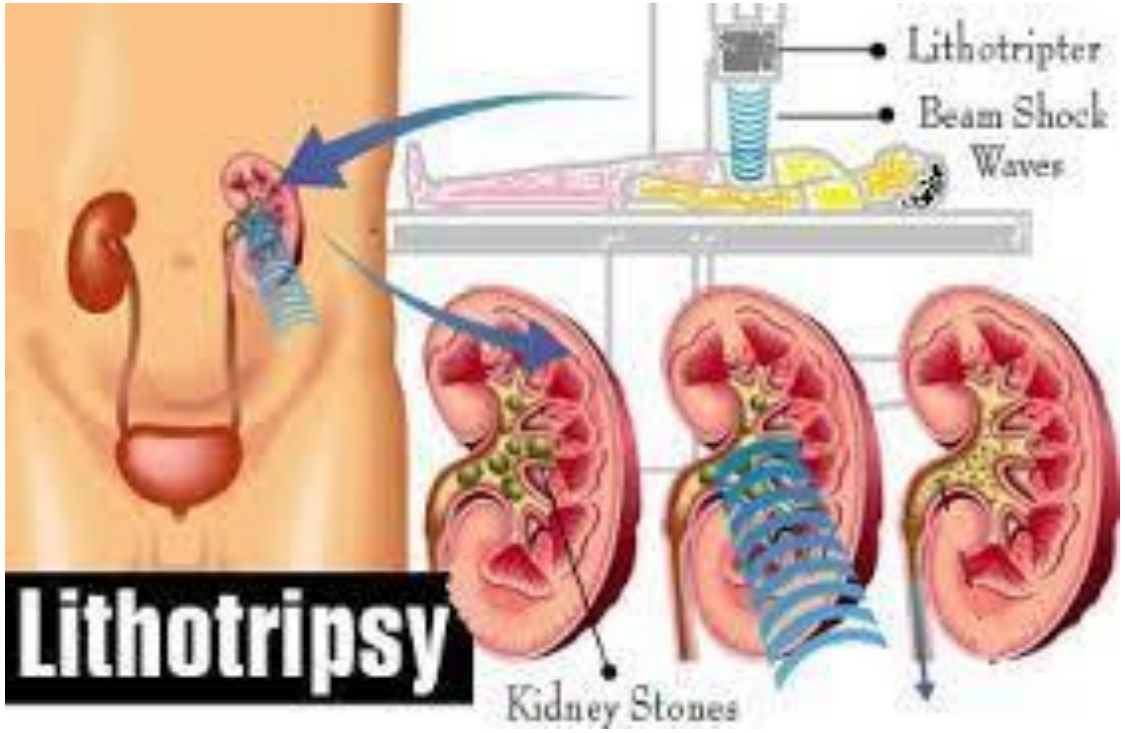
- Significant perinephric hematoma, residual stones in the ureteral tract, sepsis, renal trauma, and colic.

- Multiple SWL may often be required, That may subsequently impair renal function.

- **Not recommend SWL monotherapy as first line therapy .exception** : in patients with small stone burdens (stone area less than 500 mm^2) who have normal collecting system anatomy.

- If SWL monotherapy is used, a **stent should be placed** to ensure adequate drainage of the kidney.

Shock-wave lithotripsy



Post-procedure monitoring

- Periodic monitoring (**every 6 to 12 months**) with urologic imaging (KUB, ultrasound, or CT) is indicated after successful therapy since new stone formation **can occur**, occasionally affecting the **contralateral kidney** .

- Most likely in **women** with **pure struvite** stones and **recurrent UTI** and in patients with a **ureteral diversion.**

OUTCOMES

For determining the appropriate modality of treatment :

- Stone-free rate
- Requirement for repeat primary
- Secondary or adjunctive procedures
- Complication rates

Stone-free rate

- **Stone-free rates are also higher with procedures that are more invasive**. As an example, are approximately 50 % for SWL, and over 75 to 80% for open surgery and PNL (100 % in some reports of open surgery)

- "**Aggressive PNL**" with multiple nephrostomy tracts appear to **improve stone-free rates**, while minimizing the need for second look nephroscopy procedures .

Residual stone fragments

- A persistent stone-free state is also dependent upon complete removal of **all large stone fragments.**

- The persistence of fragments **more than 5 mm in size at three months** is associated with a **very high incidence of progressive stone growth.**

- The stone-free and infection-free rate at **three years is approximately 90 %** if all fragments are removed during the initial therapy .

- In addition to antibiotics, patients with **small fragments that persist ≥ eight weeks after SWL** may benefit from the administration of **40 to 60 mEq of potassium citrate per day** to increase urinary citrate excretion; this therapy also appears to benefit patients with calcium oxalate stone.

Repeat procedures

- Patients treated with **PNL** require **one to two** separate procedures.
- Combination **PNL plus SWL** often requires **three** procedures.
- **SWL alone** requires **three to four** procedures.

❖ With all procedures, **the size and complexity** of the stone in large part determines the success rate and need for repeat procedures.

Acute complications of surgical methods

- Perforation of the renal pelvis
- Hydrothorax/pneumothorax
- Perirenal hematoma
- Significant blood loss
- Vascular injury
- Colon injury
- Urinoma or prolonged urine leak
- Sepsis
- Pulmonary embolus
- Stent migration
- Renal impairment
- Wound infection
- Secondary unplanned interventions
- Transfusion requirement
- Nephrectomy
- Death

Acute complications of surgical methods…

- The **overall acute complication** rate is possibly **lowest for PNL and highest for open surgery and SWL**.

- **Septic complications are more common with SWL alone** than with combination SWL and PNL or open procedures

Long-term complications

- Stone recurrence
- Growth of residual stone fragments
- Renal impairment
- Loss of the kidney following surgery

- For **SWL and PNL**, stone recurrence and growth rates would be expected to be similar to an **open procedure** .

- **The method of removal should not have an effect on the propensity for recurrent stone formation or growth of residual stone fragments.**

SUMMARY

- The most important biochemical risk factor for uric acid nephrolithiasis is a **persistently low urine pH.**
- Common clinical conditions that increase the risk of uric acid stone formation include gout, chronic diarrhea, diabetes, and the metabolic syndrome.
- In patients with uric acid nephrolithiasis, we recommend urinary alkalinization and an increased fluid intake .
- Alkalinization is generally performed with **potassium citrate or potassium bicarbonate**, and should target a **urine pH :6.5 -7**.
- In patients who **continue** to form uric acid stones despite urinary alkalinization and a higher fluid intake, we recommend treatment with a xanthine oxidase inhibitor.

SUMMARY …

- Staghorn calculi refer to branched stones that fill all or part of the renal pelvis.
- These stones are strongly associated with UTI and persistent infection of the stone.
- Staghorn calculi can lead to sepsis, deterioration of kidney function, and ESRD if left untreated.
- Since medical therapy alone is usually not successful, most patients require definitive surgical treatment.
- The major surgical alternatives for staghorn calculi include PNL, SWL, the combination of PNL and SWL, and open surgery.
- For patients with a staghorn stone in a non or poorly functioning kidney, especially if it is chronically infected, **nephrectomy** is a reasonable treatment option.

Reference

1. Brenner and Rector's The Kidney, 2020
2. Up toDate 2022
3. Primer On Nephrology 2022

Thank You
For Your
Attention