An Update on Kidney Stones

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How kidney stones are formed

- Kidney stones (calculi) are formed from substances normally found in the urine.
- Small crystals may form when calcium or other chemicals become too concentrated in the urine.
- Over time, these crystals may grow into stones.

How kidney stones are formed

- Most kidney stones are formed of calcium-containing material, primarily calcium oxalate.
- Stones can also be made of other substances, such as uric acid, struvite (magnesium ammonium phosphate), or cystine.
How kidney stones are formed

- Several recent studies suggest that we may need to change our thinking about the initial steps in the process of stone formation.

- **Traditional belief**: initial events are intratubular crystal formation followed by crystal attachment and stone growth.

How kidney stones are formed

- **New evidence suggests**: initial crystal forms in the medullary interstitium and is composed of calcium phosphate.
- Calcium phosphate crystals then erode through the papilla (the classic Randall’s plaque).
- Act as a nidus for calcium oxalate deposition.

Kidney stone facts

- Kidney stones vary in size and shape.
- They can range from sand particles to the size of golf balls.
- Kidney stones can be smooth or jagged.
Kidney stones result when urine becomes too concentrated, substances in the urine crystalize to form stones. Symptoms arise when the stones begin to move down the ureter causing intense pain. Kidney stones may form in the pelvis or calyces of the kidney or in the ureter.
Types of Kidney Stones

Renal stones consist of several different categories:

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Radiolucent Stones

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Most Common Stones

- Calcium Oxalate, dihydrate
- Uric Acid
- Brushite
- Hydroxyapatite
- Struvite
- Cystine
- Xanthine
Most Common Kidney Stones

- **Calcium Stones.**
  - About 70% to 80% of all kidney stones are composed of calcium, usually combined with oxalate, or oxalic acid.
  - About 6% of calcium stones are composed of calcium phosphate (called brushite).

Kidney Stones

- **Uric Acid Stones.**
  - Uric acid can constitute as many as 40% of kidney stones in some countries.
  - Uric acid is produced in the liver and enters the bloodstream, where most passes into the kidneys and is eliminated in urine.
  - Often, uric acid stones occur with calcium stones.

Most Common Kidney Stones

- **Struvite Stones.**
  - Worldwide, they compose 30% of all kidney stones.
  - In the US less than 15% of all stones are struvite.
  - Most occurring in women.
  - The incidence of these stones may be declining in America, perhaps because of better control of urinary tract infections.
Most Common Kidney Stones

Cystine Stones
- About 2% of stones in adults
- Up to 8% of kidney stones in children

Xanthine Stones
- Extremely uncommon
- Usually occur as a result of a rare genetic disorder.

Kidney Stones

Calcium Stones.
- Oxalate is found in a number of common vegetables, fruits, and grains.

Uric acid
- Formed from a breakdown in purine, a nitrogen compound found in protein.

Most Common Kidney Stones

- Brushite
  - A unique form of calcium phosphate stones that have a tendency to recur quickly

- Hydroxyl Apatite
  - Complex calcium phosphate with attached molecules of hydroxyl, fluorine, and sometimes other elements.
  - Apatite is a fundamental mineral component in bones and teeth
  - In kidney stones, carbonate substitutes for some of the phosphate, making a mineral that is relatively poorly crystallized.
  - Forms a nucleus upon which other urinary minerals are deposited
Most Common Kidney Stones

- **Struvite stones**
  - Made of magnesium ammonium phosphate
  - Are almost always associated with certain urinary tract infections
- **Cystine Stones**
  - Caused by a build-up of the amino acid cystine, a building block of protein.
  - Tendency to form these stones is inherited.
  - They are marked by rapid growth and recurrence, which, if not treated promptly, can eventually lead to kidney failure

Most Common Kidney Stones

- **Xanthine Stones**
  - Composed of xanthine, a nitrogen compound
  - Caffeine is a derivative of this substance.

Who Gets Kidney stones

- For unknown reasons, the number of people in the United States with kidney stones has been increasing over the past 30 years.
- Caucasians are more prone to develop kidney stones than African Americans.
- Stones occur more frequently in men.
- A person with a family history of kidney stones may be more likely to develop stones.
Who Gets Kidney Stones?

- The prevalence of kidney stones rises dramatically as men enter their 40s and continues to rise into their 70s.
- For women, the prevalence of kidney stones peaks in their 50s.
- Once a person gets more than one stone, other stones are likely to develop.

More Risk Factors for Kidney Stones

These factors may increase your risk of developing kidney stones:

- **Lack of fluids.**
  - especially water
  - urine is likely to have higher concentrations of substances that can form stones.
  - more likely to form kidney stones if you live in a hot, dry climate or exercise strenuously without replacing lost fluids.

- **Family or personal history.**
  - If someone in your family has kidney stones, you're more likely to develop stones.
  - Prior hx of one or more kidney stones

- **Age, sex and cultural background.**
  - Most people who develop kidney stones are between 20 and 70 years of age.
  - Men are more likely to develop kidney stones than are women.
  - The lifetime risk of stone formation in the United States is approximately 12% in men and 6% in women.
  - The risk in blacks is one fourth that of whites.

Risk Factors for Kidney Stones

- **Dietary Factors.**
  - Based on physiologic principles and published studies, several dietary factors appear to increase the risk for nephrolithiasis.
  - Animal protein
  - Oxalate
  - Sodium
  - Sucrose
  - Vitamin
  - The impact of calcium intake on the risk for stone formation has been clarified over the past decade.
  - Lower calcium intake was associated with an increased risk for stone formation.

- **Limited activity.**
  - more prone to develop kidney stones if you're bedridden or very sedentary for a long period of time.
  - Partly because limited activity can cause your bones to release more calcium.
Risk Factors for Kidney Stones

- **Obesity.**
  - High body mass index (BMI)
  - Increased waist size
  - And weight gain have been linked to kidney stones in long-term studies of large populations.
  - Relationship is strongest in women.

- **High blood pressure.**
  - High blood pressure doubles your risk of forming kidney stones.
  - Gastric bypass surgery, inflammatory bowel disease or chronic diarrhea.
    - Changes in the digestive process affect your absorption of calcium
    - Increase the levels of stone-forming substances in your urine.

Systemic Disorders Associated with a Higher Risk for Stone Formation

- **Crohn's disease**
- **Primary hyperparathyroidism**
  - May be found in 5% of stone formers
- **Gout**
- **Diabetes mellitus**
- **Renal tubular acidosis**

Role of Nutrition

- **Calcium**
  - Low calcium intake
  - Increases oxalate absorption
  - Increases urinary excretion.
  - Also possible that other factors in dairy products, the major source of dietary calcium, may reduce the risk for stone formation.
  - Higher intake of calcium and increased potassium consumption reduce the risk.
Role of Nutrition

- Higher animal protein intake
  - May raise urine calcium and uric acid excretion
  - Decrease urinary citrate, thereby increasing the risk for stone formation.
- Higher sodium or sucrose intake
  - Increases urine calcium excretion
- Potassium supplementation
  - Decreases calcium excretion

Role of Nutrition

- In a few randomized controlled trials of dietary interventions, notably, in a randomized trial in men with hypercalciuria and recurrent calcium oxalate stones
  - A low-calcium diet (400 mg/day) was compared with a diet containing 1200 mg of calcium along with low sodium and low animal protein intake.\textsuperscript{[1]}
  - Men assigned to the higher-calcium intake group were less likely to experience stone recurrence.

Role of Nutrition

- Although calcium oxalate is the most common stone, insufficient information is available on the role of dietary oxalate
  - Lack of complete and reliable information on the oxalate content of many foods
  - Other contributors to oxalate formation (endogenous generation and metabolism of ingested protein) remain incompletely described.
Role of Nutrition

- Fluid Intake
  - Fluid intake is the primary determinant of urine volume.
  - Daily urine volume is a crucial factor in stone formation
  - Risk increases as urine volume falls
    - Especially when urine output is less than 1 L/day.

Medications

HIV/AIDS patients are at high risk for stones

- mainly due to medications
- Over 10% of HIV patients who take Indinavir develop stones
- Risk is even higher in HIV patients who have hepatitis B or C
- Hemophilia
- Who are very thin
- Receiving the antibiotic combination TMP-SMX
- In one study of HIV patients taking a combination of indinavir, zidovudine, and lamivudine, 36% developed kidney stones

Other Medications

- Certain cancer chemotherapies can cause kidney stones.
- Taking medications for long periods that change the acidic content of urine
- Antacids, may increase susceptibility for kidney stones.
Kidney Stones - Symptoms

- Kidney stones often do not cause any symptoms.
- Between 70% and 90% of crystals remain tiny enough so that they can travel through the urinary tract and pass out of the body in the urine without being noticed.

Kidney Stones - Symptoms

- When they cause symptoms, kidney stones have been described as one of the most painful disorders to afflict humans.
- The pain that they cause is sometimes referred to as renal colic.

Symptoms

- A stone residing in the kidney usually causes no symptoms until it moves.
- It is not the movement of the stone which is painful.
- Kidney stone pain occurs when there is blockage within the urinary system.
- Pain usually occurs when the stone moves out of the kidney and into the ureter.
- The narrowest point in the urinary system is where the ureter enters the bladder - most common site for stones to obstruct the urinary system.
Symptoms

- First symptom of a kidney stone is extreme pain
- Begins suddenly when a stone moves in the urinary tract and blocks the flow of urine.
- Sharp, cramping pain in the back and side in the area of the kidney or in the lower abdomen.
- Sometimes nausea and vomiting occur.
- Later, pain may spread to the groin.

Symptoms

- If stone too large to pass easily, pain continues as the muscles in the wall of the narrow ureter try to squeeze the stone into the bladder.
- As stone moves and the body tries to push it out, hematuria may occur
- As the stone moves down the ureter, closer to the bladder, a person may feel the need to urinate more often or feel a burning sensation during urination.
- If fever and chills accompany any of these symptoms, an infection may be present.

Complications

Possible Complications

- Decrease or loss of function in the affected kidney
- Kidney damage, scarring
- Obstruction of the ureter (acute unilateral obstructive uropathy)
  - Usually temporary and causes no lasting damage
  - If the obstruction progresses silently, infection may occur
  - Can be serious
  - Warrants prompt attention.
- Recurrence of stones
- Urinary Tract Infection
Complications

- Kidney Failure.
- Very rare for kidney stones to cause kidney failure.
- Some people have risk factors that make them more susceptible to this serious complication.
- They include the following:
  - Very frequent recurrences (such as in people with cystine stones or other inherited forms of kidney stone disorders).
  - Accompanying episodes of urinary tract infections with obstruction, a particular risk with struvite stones.
  - A history of multiple urologic procedures for kidney stones.
  - Greater size of the kidney stone gravel.

Recurrence

- Risk for Recurrence
- Without preventive treatment:
  - Calcium stones recur in 10% of patients within a year of the first attack.
  - In half of patients within five to seven years.
  - Individual risk for recurrence varies depending on the stone and the underlying condition.

Pathogenesis

- Most stones do not contain one single crystal type.
- Mixture with one or two types that predominate.
- Kidney stones also contain an organic material upon which the mineral is deposited.
- The predominant matrix component is protein.
Pathogenesis

Supersaturation.
- A solution that contains any material at a concentration above that material's solubility is said to be supersaturated with respect to that material.
- Involves salts that are carried in urine.
- Such salts may include calcium oxalate, uric acid, cystine, or xanthine.
- Can become extremely concentrated under certain circumstances:
  - Volume of urine is significantly reduced;
  - Abnormally high amounts of crystal-forming salts are present.
- When concentration levels reach the point at which the salts no longer dissolve, they precipitate out and form crystals.
- Different factors may be involved in either reducing urine volume or increasing the levels of the salts.

Pathogenesis

Deficiencies in Protective Factors.
- Normally, urine contains protective factors
  - Magnesium
  - Citrate
  - Pyrophosphate
  - And various proteins and enzymes
These compounds may protect against stone formation in various ways:
- Allowing salt in the urine to be at higher-than-normal concentrations without forming crystals.
- Preventing crystal formation.
- Coating the crystals and preventing them from adhering to the tube surface.
- Deficiencies in these protective substances, therefore, cause stones.

Pathogenesis

Changes in the Acidity of the Urine.
- Changes in the balance of acid to alkaline in the urine can affect stone precipitation.
- Uric acid and cystine stones thrive in acidic urine.
- Calcium phosphate and struvite stones thrive in alkaline.
Pathogenesis

- Factors that Bind Crystals to the Kidney Tubules.
- Researchers are studying the cells lining the kidney tubules in order to understand how and why early crystals bind to the tubes long enough to form stones.
- Under investigation are elevated levels of substances that either cause crystals to adhere to the tubes or deficiencies in those that prevent them from sticking.

Calcium Stones

- A number of medical conditions and drugs can affect digestion and intestinal absorption of calcium or oxalate.
- Excess Calcium in the Urine (Hypercalciuria). About 70% of calcium-containing stones caused by hypercalciuria.
- Definition of hypercalciuria:
  - Urine calcium excretion greater than 300 mg/day in men
  - 250 mg/day in women
  - Or 4 mg/kg/day on a 1000-mg/day calcium diet

- With this definition
  - Approximately 20 to 40% of patients with calcium stone disease will have hypercalciuria
  - Needs further discussion
- A number of conditions may produce hypercalciuria.
- Many are due to genetic factors
- Most cases are idiopathic
Calcium Stones

- Calcium oxalate supersaturation is dependent on urinary volume
- Overly efficient intestinal absorption of calcium
- Renal calcium leak—the filtering processes in the kidney fail, causing an increase of calcium in the urine.
- In most of these conditions, genetic factors conspire to increase calcium absorption in the intestine.
- Example: Excess chloride—may lead to excess calcium.
  - A gene known as CLCN5, which regulates chloride in the urine, is defective in many patients with calcium stones.

Calcium Stones

- High urinary levels of sodium result in increased levels of calcium.
- Defects in the kidney tubules transport system
  - can cause imbalances in sodium and phosphate
  - result in elevated urinary calcium
- A high Na+ diet can also produce this effect.

Calcium Stones

- Hyperoxaluria
- Defined as urinary oxalate excretion greater than 45 mg/day.
- Elevated urinary oxalate excretion may be present in
  - up to 40% of male
  - 10% of female stone formers.
- However, hyperoxaluria frequently found in individuals who do not have a history of stone disease.
Calcium Stones

- Hyperoxaluria is defined as either primary or secondary.
- Primary hyperoxaluria
  - an inherited disorder
  - excess oxalate in the urine is the primary problem.
- Secondary hyperoxaluria
  - caused by specific conditions that result in excess urinary oxalate.

- Secondary hyperoxaluria
  - usually caused by excessive intake of dietary oxalates (found in a number of common vegetables, fruits, and grains).
  - abnormalities in the metabolism of oxalates.
  - Such defects may be due to various factors, such as the following:
  - Deficiencies of pyridoxine (vitamin B6).
    - Severe vitamin B6 deficiencies (usually due to genetic disorders) can result in overproduction of oxalic acid.

- Short bowel syndrome
  - may result from surgery in the small intestine
  - marked by inability of intestines to absorb fat and nutrients properly (malabsorption).
  - calcium may bind to unabsorbed fat instead of to oxalates.
  - leaves excess oxalate, which is absorbed by the intestine and excreted into the kidney.
Calcium Stones

- Hypercalcemia
  - generally occurs when bones break down
  - release too much calcium into the bloodstream.
  - This is a process called resorption, which can occur because of the following:
  - Hyperparathyroidism.
  - Overactive parathyroid glands cause about 5% of calcium stones.
  - people with this disorder have at least a 20% chance of developing kidney stones.
  - Women are more likely to have this disorder than men.

Calcium Stones

Renal tubular acidosis

- causes acid and alkaline imbalance
- increases calcium levels in the bloodstream
- it also reduces citrate levels.

Calcium Stones

- Hyperuricosuria
  - Definition:
    - greater than 800 mg/day in men
    - or 750 mg/day in women.
  - increased frequency of stone disease in persons with gout
    - double-blind trial showing that allopurinol successfully decreased recurrence rates of calcium stones in patients with hyperuricosuric suggests a causative role.
  - the mechanism by which uric acid may promote calcium oxalate stone formation remains uncertain.
Calcium Stones

- Hypocitraturia
- Citrate inhibits crystal growth and aggregation.
- Definition: hypocitraturia
  - <320 mg/day for men and women
  - at increased risk for stone formation
  - unclear whether increasing urinary citrate above the normal range provides additional protection
  - some of the factors that govern citrate in normal individuals are known
  - do not completely account for the higher renal tubular reabsorption of citrate present in idiopathic calcium stone formers with hypocitraturia

Calcium Stones

- Hypocitraturia
  - increases the risk for uric acid stones
  - most likely contributes to about a third of all kidney stones.
- Many conditions can reduce citrate levels
  - Renal tubular acidosis.
  - Potassium or magnesium deficiency.
  - Urinary tract infection.
  - Kidney failure.
  - Chronic diarrhea.

Uric Acid Stones

- The major determinant of uric acid supersaturation and subsequent uric acid stone formation is urinary pH
- Conditions observed in patients with uric stones:
  - Patients produce lower than normal amounts of urine.
  - Patients have high amount of uric acid in the urine (hyperuricosuria).
  - This is less often a cause of uric acid than acidic or low volume of urine.
  - Hyperuricosuria may be due to a high intake in protein,
    - can be an inherited condition
    - associated with high levels of uric acid in the blood (hyperuricemia).
Uric Acid Stones

Conditions may contribute to or cause uric acid stones:
- Gout.
  - Uric acid and other kidney stones are present in 10% to 25% of patients with primary gout.
  - Prevalence more than 1,000 times that of the general population.
- Possibly kidney abnormalities that reduce ammonia production.
  - Particularly in people with diabetes or insulin resistance.
- Genetic factors.
- Hypocitraturia.
- Diets overly rich in animal proteins.
- Certain medications (chemotherapy agents, diuretics, and salicylates).
- Binge drinking.
- Fasting.
- Lead toxicity.
- Hematologic diseases (leukemia, certain uncommon anemias, multiple myeloma, and lymphomas).
- Chronic diarrhea.

Struvite Stones

- Form only when the upper urinary tract is infected with urease-producing bacteria such as:
  - Proteus mirabilis
  - Klebsiella pneumoniae
  - Providencia species
- Women are twice as likely to have struvite stones than men.
Struvite Stones

- Hydrolysis of urea by urease results in
  - supraphysiologic urine pH higher than 8.0
  - enzymes raise urine concentrations of the ammonia
  - composes the crystals
  - formation of struvite (MgNH4PO4·H2O)
  - If infection is inadequately treated, struvite stones may grow quickly
  - fill the renal collecting system
  - result in a staghorn calculus

Cystine Stones

- Cystine stones
- form in individuals with an uncommon autosomal recessive disorder
  - cause abnormal transport of amino acids in the kidney and gastrointestinal system
  - lead to a build-up of cystine
  - Cystine is clinically significant because of its poor solubility in urine
Xanthine Stones

- May develop in patients being treated with allopurinol for gout

Assessment/Diagnosis

- Physical examination alone will rarely make the diagnosis, may guide evaluation
- Patient will typically be in obvious pain
- Cannot find a comfortable position.
- May be ipsilateral CVA tenderness

Assessment/Diagnosis

- Pain often accompanied by nausea and occasionally vomiting
- May radiate to different spots, depending on the location of the stone.
- If stone lodges in the upper part of the ureter
  - Pain may radiate anteriorly
- If the stone is in the lower part of the ureter
  - Pain can radiate to the ipsilateral testicle in men or ipsilateral labium in women
- If lodged at the ureterovesical junction
  - Major symptoms may be urinary frequency and urgency
- Occasionally, a patient will have gross hematuria without pain.
Assessment/Diagnosis

- Establish presence or absence of kidney stones as soon as possible so that pain management can begin if necessary. (Use physical examination, imaging techniques.)
- If a kidney stone is present, determine whether the stone is obstructing the urinary tract. (Use imaging techniques.)

Assessment/Diagnosis

- If obstruction with infection, signs of sepsis may be found.
- Laboratory evaluation is rarely diagnostic.
- Serum chemistry findings are typically normal.
- May be an elevated WBC count.

Assessment/Diagnosis

- Urinalysis should always be performed on fresh urine.
  - Will classically reveal red and white blood cells.
  - Occasionally crystals.
  - Absence of hematuria does not exclude the diagnosis.
  - If the ureter is completely obstructed, no urine will be flowing from that side into the bladder.
Assessment/Diagnosis

Along with the history, the diagnosis will be made by an appropriate imaging study
The imaging modality of choice is helical computed tomography (CT)
- high sensitivity
- ability to visualize uric acid stones (traditionally considered "radiolucent")
- no need for radiocontrast

Assessment/Diagnosis

CT detects stones as small as 1 mm
- identifies small stones that may be missed by intravenous urography.
- will reveal a ureteral stone or
evidence of recent passage (e.g., perinephric stranding or hydronephrosis)
plain abdominal radiograph (kidney-ureters-bladder) can miss a stone in the ureter or kidney, even if radiopaque
- provides no information on obstruction

Assessment/Diagnosis

Abdominal ultrasound has the advantage of avoiding radiation
this technique can image only the kidney
possibly the proximal segment of the ureter
most ureteral stones are not seen
Establish the presence or absence of kidney stones as soon as possible so that pain management can begin if necessary!!
Differential Diagnosis

- Signs and symptoms from a ureteral stone may mimic a number of other acute conditions.
  - Stone lodged at the right ureteropelvic junction may mimic acute cholecystitis
  - Stone in the distal right ureter may mimic acute appendicitis
  - Stone at the ureterovesical junction may mimic acute cystitis
  - Stone in the distal left ureter may mimic diverticulitis.

Differential diagnosis

- An obstructing stone with proximal infection may mimic acute pyelonephritis.
- Infection in the setting of ureteral obstruction is a medical emergency ("pus under pressure")
- Requires emergency drainage by placement of either a ureteral stent or a percutaneous nephrostomy tube
Differential Diagnosis

- Other conditions to consider
  - muscular or skeletal pain
  - herpes zoster
  - duodenal ulcer
  - abdominal aortic aneurysm
  - gynecologic causes
  - ureteral stricture
  - ureteral obstruction by materials other than a stone
    - blood clot or sloughed papilla

Differential Diagnosis

- In patients with documented history of nephrolithiasis
  - may often be chronic back/flank pain
- Stone disease itself rarely a cause of chronic pain
- goal should be to determine the source of the pain.

Differential Diagnosis

- Differential diagnosis of chronic flank pain includes:
  - musculoskeletal pain
  - other intra-abdominal conditions
  - drug seeking
- A thorough urologic evaluation, including appropriate radiologic studies, may curtail the long-term use of narcotics and avert frequent trips to the emergency room.
Treatment

- Pain control is a priority after definitive diagnosis has been made
  - parenteral medication is typically required
  - Narcotics and parenteral nonsteroidal anti-inflammatory drugs (NSAIDs)
  - demonstrated to be equally effective
  - NSAIDs are preferred because of fewer side effects

Treatment

- Treatment of kidney stones depend upon several factors:
  - Size of stone
  - Type of stone
  - Location of stone
  - Ability to see stone on x-ray

Treatment

- Patients symptoms
- Associated medical problems such as fever, nausea, pain, etc.
- Fortunately, most kidney stones will pass spontaneously.
- when stones require treatment
  - minimally invasive options are now available
  - patients can return to a normal lifestyle sooner.
Treatment

- Consult: A urologist should be involved in the following situations:
  - infection
  - persistent or uncontrollable pain
  - inability to pass the stone
  - urinary extravasation detected by imaging
  - high-grade obstruction with a large stone
  - a solitary kidney
  - pregnancy

- no admission required if able to tolerate oral analgesics
- instructions should be given to return if fever or uncontrollable pain develops
- usually wait several days before Urologist intervenes unless:
  - evidence of urinary tract infection
  - low probability of spontaneous stone passage (e.g., stone >6 mm; anatomic abnormality)
  - intractable pain.

Treatment - Observation
- still considered the best management for kidney stones when possible
- for a stone to pass spontaneously,
  - must be small enough to pass through the ureteral orifice and into the bladder
  - stones 5mm and under will usually pass spontaneously
  - warrant conservative treatment unless patients have persistent symptoms
## Treatment

- Stones between 5mm and 10mm
  - may or may not pass
  - must be followed closely
- Stones greater than 10mm (1cm)
  - unlikely to pass spontaneously
  - will likely be treated more aggressively

## Treatment

- Have patient strain all urine to collect stone
- Stone Analysis
- If ureteral stone:
  - Terazosin
  - Flomax
    - Becoming standard of care
    - Increases chance of passing ureteral stone to >80%
- If obstructed, relief of obstruction is the initial approach
  - this will relieve the symptoms

## Treatment

- Ureteral stent may be placed cystoscopically
- Stent can be quite uncomfortable
  - Alleviate obstruction and secondary pain
  - May cause gross hematuria
  - May help with stone passage
- Approach to stone removal is dictated by stone size, location, and composition; urinary tract anatomy
Treatment

- **Lithotripsy (Shock Wave Therapy)**
  - Originally developed in the 1980's
  - Shock wave therapy is now a standard method of treating some stones in the kidney and ureter.
  - Effective for stones up to 1.5 - 2.0 cm in size.
  - Stones larger than 2.0 cm are unlikely to be treated effectively with shock wave therapy.
  - Only stones which can be visualized with standard x-rays can be treated with most lithotripters.

- **Ureteroscopy** - This surgical procedure has replaced open surgery for the majority of kidney stones.
  - For ureteroscopic stone extraction:
    - Urologist looks into the ureter with a small (1/8 inch diameter) scope to visualize the stone.
    - Once the stone is located, it can either be removed intact via a basket or grasper.
    - It may be broken/fractured and then removed in pieces.
    - This procedure is commonly performed in conjunction with intracorporeal lithotripsy.
Treatment

- Several devices can now be used to break up a stone within the ureter to make its removal easier
- Holmium laser
  - can fracture all stones
  - causes minimal tissue damage
  - This laser is considered state-of-the-art
  - is the preferable tool for fragmenting kidney stones

Treatment

- PCNL (Percutaneous Nephrolithomy) - PCNL is a procedure used to remove large stones from the kidney
- these stones previously were treated with open surgery
- even large stones can now be extracted through a 1 inch incision

Prevention

- work-up should include appropriate clinical and laboratory evaluation
- should include a serum chemistry profile
- 24-hour urine collection
- Even if the content of the stone is known, metabolic evaluation is necessary to identify the abnormalities and guide therapeutic recommendations.
Prevention

- Dietary Modification
  - Low oxalate diet
  - Low purine diet
- Fluid Intake
  - General target is encouraging patients to drink enough fluid to produce more than 2 L of urine each day

Prevention

- Calcium Intake
- Restriction of nondairy animal protein (e.g., meat, chicken, seafood) is a reasonable option
- Reducing sodium intake to less than 3 g/day
  - May decrease urine calcium
- Potassium-rich foods should be encouraged

Prevention

- Dietary recommendations should be tailored to the patient's urinary chemistry profile
- Impact of the recommendations can be monitored by repeating the urine collections
Medications

- Thiazide diuretics
  - hydrochlorothiazide
  - chlorthalidone
    - increase calcium reabsorption in the proximal convoluted tubule and distal tubule
    - effectively lower urinary calcium excretion by 20 to 50%
- Doses required (25 to 100 mg/day) are higher than those needed for treating hypertension.

Medications

- Thiazide-induced hypokalemia can be treated with potassium citrate or amiloride
- Because of its potential to precipitate, Triamterene should be avoided in these patients
- Indapamide, though not strictly a thiazide, will also reduce urine calcium.

Medications

- Allopurinol
  - can reduce urine uric acid excretion by up to 50%.
  - Single double-blind randomized trial found that allopurinol reduced stone recurrence in individuals with hyperuricosuric calcium oxalate stone disease.
  - Other trials of allopurinol in patients not specifically selected for hyperuricosuria showed no benefit when compared with placebo
Medications

Potassium Citrate

- Systemic alkalinization with bicarbonate or citrate will lead to an increase in urinary citrate excretion.
- Most commonly used salt is potassium citrate
  - avoids the calcicnic effect of a sodium load
  - restores any potassium deficiency
- Only two randomized trials have evaluated the impact of citrate supplementation.
  - showed a reduction in the stone formation rate when compared with placebo

Medications

Magnesium

- Oral magnesium from supplements may reduce stone risk by forming soluble complexes with oxalate in the bowel or urine.
- role of magnesium supplementation remains uncertain

Questions?????