Caring for Kidney Stones

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WELL DONE MR. JONES, IT LOOKS LIKE WE'VE PASSED THAT KIDNEY STONE AT LAST!!!
Learning Objectives

- Define types of stones and risk factors associated with kidney stone development
- Describe process of kidney stone formation
- Discuss role of each medical professional/team member with emphasis on dietitian’s role in management of kidney stones
- Summarize nutritional recommendations and dietary interventions for kidney stone treatment and prevention application
Introduction to Kidney Stones

- Nephrolithiasis (Kidney Stones) – Presence of renal calculi caused by an imbalance between solubility and precipitation of salts in the urinary tract and in the kidneys.
- Prevalence in United States: 1 in 11 (8.8%)
  - Men: 10.6%
  - Women: 7.1%
- 70% increase incidence over the last reported prevalence from NHANES data
- Recurrence
  - 7-10% per year
  - 50% of kidney stone formers have a recurrence within 10 years
- Estimated $2 billion+ spent on diagnosis and management of nephrolithiasis in the United States each year
Signs & symptoms

- Hematuria
- Renal colic – severe, sharp pain (rapid onset, writhing)
  - Upper Ureter – pain radiates from flank to upper abdomen
  - Lower Ureter – pain radiates from flank to ipsilateral testicle (men) or labium (women)
  - Ureterovesical Junction – frequency or urgency
- Nausea
- Emesis

*Symptoms typically quickly improve with passing of the stone
Risk Factors for Kidney Stone Formation

- **Genetic**
  - Dent’s disease (rare condition of proximal renal tubules), idiopathic hypercalciuria, family history

- **Kidney Disease-Related**
  - PCKD, horseshoe kidney (anatomical)
  - Mellitus, hyperparathyroidism

- **Systemic**
  - Inflammatory bowel disease, GI diseases
  - RTA - Renal Tubular Acidosis (accumulation of acid in body)
Risk Factors for Kidney Stone Formation

- Sarcoidosis: (Collections of inflammatory cell in different parts of the body)

- Dietary
  - High Na, high oxalate, high protein (animal,) inadequate fluid, low K, low citrate, low Mg, etc

- Climate/Environmental
  - Heat, water loss/sweating

- Metabolic: Obesity, Diabetes
Factors favoring kidney stone development

- Increased urinary crystalloids: Supersaturated urine
- Decreased inhibitors
  - Low Magnesium (complexes with oxalate) and Citrate (complexes with calcium)
  - Low glycoprotein production:
    - Nephrocalcin (NC; renal tubular glycoprotein & urinary inhibitor of calcium oxalate crystal growth)
    - uropontin (an aspartic acid rich phosphorylated glycoprotein to inhibit stone formation)
    - Tamm-Horsfall or uromodulin (glycoproteins)
- Increased promoters: Uric acid- associated with diets high in:
  - beef, chicken, and pork, especially organ meats
  - Eggs, fish and shellfish
  - milk, cheese, and other dairy products
Factors favoring kidney stone development

- Dehydration
  - Low urine volume, supersaturated urine
- Urine pH - Important factor in production of Kidney stones:
  - Alkaline (Calcium Phosphate Stones formed), Acidic (Uric acid; calcium oxelate; cysteine stones)
- Diet
  - High protein/sodium/calcium (hypercalciuria, uricosuria (uric acid in urine), and Oxaluria (high oxalate))
- Medication
  - Furosemide: decrease urinary volume
  - Sodium bicarbonate: increase urinary calcium
Formation of kidney stones

- Crystals begin to form when Calcium Oxalate (CaOx) concentration is 4x above normal.
- Nucleation or clustering of solute molecules occurs when CaOx concentration is 7-11x higher than normal solubility.
- Supersaturation (SS) of CaOx is increased with high urine calcium and high urine oxalate in the presence of low urine volume.
- High SS of CaOx in the presence of low urine citrate drives formation of CaOx stones.
- Overall, levels of urinary SS of various solutes determines the type of renal calculi formed.
Types of Kidney Stones

- **Calcium (most common, often combination): 70-80%**
  - Idiopathic or unknown cause of calcium oxalate
  - Calcium phosphate
- **Uric Acid: 5-15%**
- **Struvite: 10-20%**
  - may form after you have a UTI, develop suddenly and become large quickly.
- **Cystine: 1% or less**
## Types of stones

<table>
<thead>
<tr>
<th>Type</th>
<th>Frequency</th>
<th>Sex</th>
<th>Crystals</th>
<th>Radiography</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium oxalate/mix</td>
<td>75%</td>
<td>M</td>
<td>Envelop</td>
<td>Round, radiodense, sharply outlined</td>
</tr>
<tr>
<td>Calcium phosphate</td>
<td>5%</td>
<td>F&gt;M</td>
<td>Amorphous (alkaline urine)</td>
<td>Small, radiodense</td>
</tr>
<tr>
<td>Uric acid</td>
<td>5-15%</td>
<td>M/F</td>
<td>Diamond acid urine</td>
<td>Round/staghorn, radiolucent, filling defect</td>
</tr>
<tr>
<td>Struvite</td>
<td>10-20%</td>
<td>F</td>
<td>Coffin lid (infection/urea splitter)</td>
<td>Staghorn, laminated radiodense</td>
</tr>
<tr>
<td>Cystine</td>
<td>1% or less</td>
<td>M/F</td>
<td>Hexagon</td>
<td>Staghorn, radiodense</td>
</tr>
</tbody>
</table>
THE TEAM

- **Urologist**
  - Surgical management for treatment
  - Acute
  - Stone removal: extracorporeal shockwave lithotripsy (ESWL) or surgery (typically if stone is > 5mm or there is sign of obstruction)

- **Nephrologist**
  - Medical management for treatment & Prevention

- **Dietitian**
  - Referral from nephrologist or urologist
  - Nutritional management for treatment
  - Prevention of recurrence through dietary lifestyle changes
  - Often collaborates with nephrologist (reviewing/assessing 24-hour urinalysis or Litholink)
Evaluation of Stone disease

- Medical/surgical history
  - Prior kidney stones and interventions (i.e. surgery)
  - Composition of kidney stones (if known)
  - Diseases that increase risk (i.e. malabsorptive GI disorders, gout, etc.)
- Family history
- Social history
  - Occupation, lifestyle
- Usual dietary intake (24-hour diet recall)
- Dietary/fluid intake history
- Two 24 hour urinalysis for initial evaluation (no interventions prior to obtaining in order to analyze stone risk)
- Blood tests: Serum Na, K, CO₂, BUN, Cr, Ca, phosphorus, uric acid and PTH
- Upon evaluation, diet and medical treatments prescribed as appropriate
24-Hour Urinalysis (Litholink)
# 24-Hour Urinalysis (Normal Values)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Normal Values</th>
<th>Notes</th>
</tr>
</thead>
</table>
| Calcium            | <250 mg/d (Males)  
<250 mg/d (Females) | ↑ with idiopathic hypercalciuria, high Na diet, high protein diet  
↓ with bone disease |
| Phosphorus         | 0.6-1/2 g/d            | ↓ with bowel disease, malnutrition, large amount of food intake       |
| Magnesium          | 30-120 mg/d           | ↓ with some laxatives, malnutrition, malabsorption                   |
| Oxalate            | 20-40 mg/d            | ↑ with high oxalate diet, high vitamin C consumption  
if > 80, intestinal (Inflammatory bowel disease) or oxalosis |
| Citrate            | >450 mg/d (Males)  
>550 mg/d (Females) | ↓ RTA, hypokalemia, high animal protein diet, acidosis, diarrhea     |
| Uric Acid          | <0.8 g/d for males  
<0.75 g/d for females | ↑ with high animal protein diet (high purine), alcoholic beverages, overproduction |
| Volume             | > 2,000 mL/d          | ↓ with low fluid intake                                              |
| pH                 | 5.8-6.2               | ↓ RTA, urea splitting infection, acidosis, high animal protein intake (high purine content)  
↑ vegetarian diet, high citrus consumption, soft drink |
| Sodium             | 50-150 mEq/d          | ↑ with high Na diet  
↓ with low volume                                                        |
| Potassium          | 20-100 mEq/d          | <20 mEq Bowel disease, diuretics, laxatives                           |
| Chloride           | 70-250 mEq/d          | ↑ with high protein diet                                              |
| Urea Nitrogen      | 6-14 g/kg/d           | ↑ with high protein diet                                              |
| Protein Catabolic Rate (PCR) | 0.8-1.4 g/kg/d | ↑ with high protein diet                                              |
| Sulfate            | 20-80 mEq/d           | ↑ with high protein diet                                              |
| Ammonium           | 15-60 mM/d            | ↑ pH > 7 urea splitting infection  
↓ pH < 5.5 CRI, UA stones, gout                                        |
| Creatinine         | 18-24 mg/kg (Males)  
15-20 mg/kg (Females) | ↑ with more than 24 hour collection  
↓ with under collection                                                  |
Nutrition assessment

- Dietitian have a crucial role in kidney stone care (both treatment and prevention)
- Nutritional risk factors assessed by dietary intake assessments in conjunction with 24-hour urinalyses and provide therapeutic recommendations
- Dietitian should evaluate dietary intakes of:
  - Calcium, oxalates, sodium, protein (both animal and plant sources)
  - Dietary supplements (i.e. vitamin C, vitamin D, MVT, etc.)
  - Fluid intake
- Dietary Assessment Methods:
  - 24-hour diet recall
  - food frequency questionnaire
  - food record diet history (most appropriate/reliable during 24-hour urine collection or 1-2 days before collection
Fluids

- Low fluid intake → low urine volume
- Baseline (Minimum) Fluid Requirements:
  - Adults:
    - 30 mL or 1 ounce of fluid per kg body weight

ESRD patients are exception. Patients are typically encouraged to drink well above the minimum with current recommendations at 2.5L/d or above for adults, 2.4-3L/d for adolescents (1.5x maintenance). Additional factors that may increase daily fluid needs include heavy exercise, hot weather, increased GI losses.
What Type of Fluids?

- All drinks count towards fluid intake (even coffee,) but the bulk will likely be from water.
- Choose water, milk, 100% fruit juice (orange, grapefruit, etc.) homemade lemonade/limeade and other low-calorie, low-sugar drinks.
- Limit and/or avoid sodas (especially dark-colored,) iced teas, sports drinks (i.e. Gatorade, Powerade, etc) and other sugar beverages as able.
Calcium

- Adequate dietary intake of calcium decreases risk with low dietary intake increasing risk
  - Calcium binds oxalate in the intestines
  - Recommend one serving of a calcium-rich food/drink (dairy, fortified calcium foods, etc.) with every meal
- Calcium supplements may be necessary if patient with inadequate dietary calcium intake
  - Take with meals for oxalate binding (excessive calcium supplement intake can exacerbate hypercalciuria)
- Recommended Calcium Intake:
  - Adults: 800-1200 mg/d
  - Vitamin D 1000iu
Sodium

- High sodium intake decreased passive calcium (Ca) reabsorption in proximal tubule and increased urine calcium excretion.

- Chronic excess salt (NaCl) intake promotes metabolic acidosis causing release of calcium from the bone.

- Recommended Sodium Intake
  - Adults: 2000-3000 mg/d (low sodium diet)
Oxalate

- Diet rich in oxalate may have a more prominent effect in patients with idiopathic calcium oxalate kidney stones
- Urinary Oxalate Sources:
  - High oxalate foods/diet
  - Inadequate dietary calcium intake
  - Malabsorption (i.e., short gut, IBD, bariatric surgery)
  - Supplemental Vitamin C
  - High protein intake (glycine → oxalate)
  - Lack of Oxalobacter formigenes (oxalate-degrading anaerobic bacterium that colonizes in intestines)
High Oxalate Foods

- High oxalate foods contain oxalate >10mg/serving
- Moderate oxalate foods contain 2-10mg/serving
- Wide range of oxalate content of foods and can vary depending on database

- Spinach
- Swiss chard
- Beets
- Rhubarb
- Soybean/soy products
- Peanuts/peanut butter
- Almonds
- Chocolate/Cocoa
- Sweet potato
- Wheat germ
- Black teas
- Nutella
Oxalate

Issues with Oxalate:
- The highest oxalate foods are often the healthiest
- High oxalate foods also contain phytates and magnesium (Mg) which are also inhibitors of calcium stones
- The oxalate content of foods is not standardized
- Patients/families may be confused when following a healthy diet, but must limit/avoid high oxalate foods

Recommended Oxalate Intake:
- Adults: 40-50 mg/d
Protein

- High dietary animal protein intake \(\rightarrow\) increased incidence of kidney stones
  - Purine metabolism \(\rightarrow\) uric acid generation (alcohol, some fish, seafood, shellfish, some meats, bacon, turkey, veal, organ meats).
  - Sulfur-containing amino acid metabolism acid generation (methionine, cysteine, homocysteine, taurine).
- Increased urinary acid excretion \(\rightarrow\) precipitation of uric acid
- Calcium release from bone \(\rightarrow\) increase in urinary calcium
- Urinary citrate is decreased due to enhanced proximal tubule reabsorption that occurs with a fall in tubular pH

- Recommended Protein Intake:
  - Adults: 0.8-1.2 g/kg/d (low-moderate protein diet)

*Ideal body weight or adjusted body weight is used if patient is overweight/obese or underweight*
Acid Ash and Alkaline Ash Foods

- Acid Ash Foods acidify the urine (lower pH)
  - Meat, fish, shellfish, egg
  - Cheese, peanut butter
  - Bacon, nuts (walnuts)
  - Whole wheat, crackers, cereal, macaroni, noodles, rice
  - Corn, lentils
  - Cranberries, plums, prunes

- Alkaline Ash Foods alkalize the urine (raise pH)
  - Milk, butter milk
  - Almonds, chestnuts, coconuts
  - All type of vegetables except corns/lentils
  - Beets, Swiss chard, kale, mustard greens, spinach, turnips
  - All types of fruits except cranberries, plums and prunes
  - Molasses
Citrate

- **Citrate** increases urine pH which helps decrease calcium oxalate supersaturation as citrate will complex with Ca ion and inhibit crystallization.

- Most citrus fruits (oranges, lemons, limes, grapefruit) contain high amounts of citrate as well as potassium, which enhances citrate excretion (lemons and limes are the best sources of citrate).

- Patients with hypocitraturia may benefit from taking 4 ounces of fresh lemon or lime juice daily (mixed in water/drinks or in foods) to help normalize urine citrate levels.
Potassium & Magnesium

- Most fruits and vegetables are rich in potassium.
- Patients with low urinary citrate and urine pH may be prescribed potassium citrate.
- Monitoring 24-hour urinary excretion of potassium is crucial for compliance.
- Dietary potassium intake (i.e., fruits & vegetables) may increase urine pH resulting in decreased SS of CaOx and uric acid as well as increase citrate and urine volume.

- Magnesium-rich food sources include avocados, legumes, nuts, whole grains, etc.
- Mg complexes with oxalate and decreases SS of CaOx in the urine (may also increase pH).
- Also, magnesium can bind with oxalate in the GI tract to reduce oxalate absorption (magnesium supplements are not typically recommended).
Vitamins C & D

- Vitamin C (ascorbic acid) metabolizes to dehydroascorbic acid and eventually converted to oxalate
- High vitamin C intake of 500-1000mg+ per day (especially in supplement form) increases endogenous oxalate and risk for stone formation
- Recommended Vitamin C Intake:
  - Pediatrics: DRI for Age
  - Adults (DRI):
    - Men – 90 mg/d
    - Women – 75 mg/d
- If vitamin D insufficiency or deficiency is present, short term supplementation may be necessary to replete (i.e. 1,000 international units per day for adults)
 Management of kidney stones (overview)

<table>
<thead>
<tr>
<th>Abnormality</th>
<th>Evaluate</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypercalciuria</td>
<td>Urine Na and urea nitrogen</td>
<td>Na, protein restriction, Thiazide, optimal calcium intake (not low)</td>
</tr>
<tr>
<td>Hypercalcemia</td>
<td>PTH, ionized Ca, vitamin D, malignancy, thyroid, bone disease</td>
<td>Parathyroidectomy, treat underlying disorder</td>
</tr>
<tr>
<td>Hyperoxaluria</td>
<td>Dietary oxalate, low dietary Ca, vitamin D, sweeteners, GI-related disease, gastric bypass, ethylene glycol, enzyme deficiencies</td>
<td>Restrict oxalate (adults moreso than in pediatrics as children are growing), supplement magnesium (if indicated), Ca, pyridoxine, cholestyramine</td>
</tr>
<tr>
<td>Hypocitraturia</td>
<td>Urinary citrate, serum potassium, creatinine, malabsorption, RTA, acetazolamide</td>
<td>Alkali therapy (potassium citrate), sodium citrate if volume depleted</td>
</tr>
<tr>
<td>Hyperuricosuria</td>
<td>Dietary purines, gout</td>
<td>Purine restriction, allopurinol, alkali therapy</td>
</tr>
<tr>
<td>Acidic urine (pH)</td>
<td>Exclude chronic diarrhea, gout, ileostomy</td>
<td>Alkali therapy</td>
</tr>
<tr>
<td>Low urine volume</td>
<td>24 hour urine volume</td>
<td>At least 2.5 liters/d</td>
</tr>
</tbody>
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Summary

- Dietitians play a crucial role in management and prevention of kidney stones.
- Important to collaborate with multidisciplinary team, especially the Nephrologist for optimal treatment and management.
- Identify dietary risk factors based upon nutrition assessment and evaluation of 24-hour urinalysis in order to apply appropriate interventions.
References