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 a 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

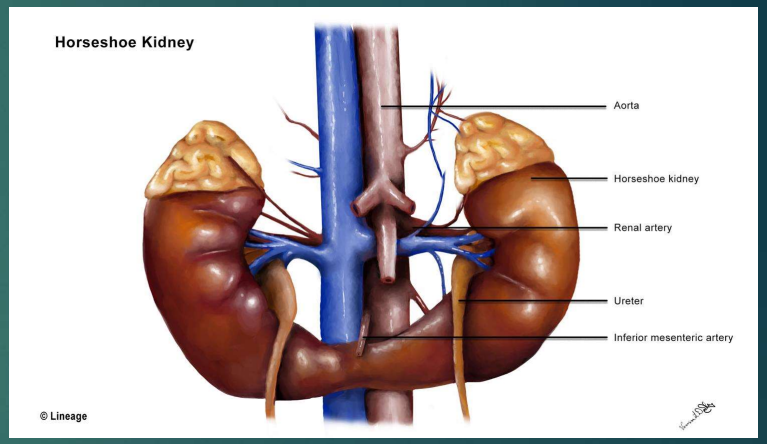
Signs & symptoms

- 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 oxelate 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

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

THE TEAM

- Urologist
  - Surgical management for treatment
  - Acute
  - Stone removal: extracorpeal 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 (ie 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, CO_2, 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)

Calcium	<250 mg/d (Males) <250 mg/d (Females)	↑ Idiopathic hypercalciuria, high Na diet (high urine Na), high protein diet ↓ with bone disease
Phosphorus	0.6-1/2 g/d	↓ with bowel disease, malnutrition, with 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

Lab Ranges courtsey of Litholink Corp, Chicago, IL

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/dfor 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 oxelate 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 exacerabate hypercalciuria)
- Recommended Calcium Intake:
  - Adults: 800-1200 mg/d
  - Vitamin D 1000iu

Sodium

- High sodium intake → decreased passive calcium (Ca) reabsorption in proximal tubule → 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 (ie: 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 → increased incidence of kidney stones
  - Purine metabolism → 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 → precipitation of uric acid
  - Calcium release from bone → 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 crucia 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 (ascorbid 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)

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

Summary

- Dietitians play a crucial role in management an 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

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