Kidney Stones

Summary of Recommendations

- Calcium oxalate stones are the most common type of stone and comprise approximately 70 to 80% of all stones.[1] If an individual has a history of kidney stones, but the type of stone has not been identified, the recommendations for individuals with calcium oxalate stones should be followed, as calcium oxalate stones are the most common type of stone in adults.[2]
- In general, it is recommended all individuals with a history of kidney stones aim for a daily urine output of 2.5L.
- It is recommended individuals with a history of stone formation or at risk for stone formation be encouraged to reduce their sodium intake to 1500 mg (65 mmol) per day not exceeding 2300 mg (100 mmol) per day.
- A moderate protein intake, to achieve but not exceed the dietary reference intake (DRI), is recommended to prevent stone formation.
- Restriction of dietary oxalate is not recommended in otherwise healthy adults, without a history of calcium oxalate stones and documented evidence of elevated urinary oxalate levels.
- Oxalate restrictions should be considered for patients with pre-existing hyperoxaluria, and conditions which increase oxalate absorption and/or fat malabsorption, such as patients with inflammatory bowel disease or a previous Roux-en-Y gastric bypass surgery. For those requiring an oxalate restriction, care should be placed in also meeting the DRI for calcium.
- It is recommended individuals achieve the DRI for calcium through dietary sources. Calcium intake through supplements is discouraged. In the case where a calcium supplement must be taken, it should be taken with food and total calcium intake (from supplements and dietary sources) should not exceed the DRI.
- For individuals with a history of oxalate-containing kidney stones, high-dose vitamin C supplements are not recommended. It is recommended all individuals regardless of stone history not exceed 2000 mg/day of vitamin C from supplements, which is the tolerable upper intake level.

- Avoid vitamin/mineral supplements that provide calcium with vitamin D (combined).
- Limit the consumption of sugar-sweetened beverages, such as juice and pop.
- Follow Canada's Guidance on Alcohol and Health (2023) related to alcohol consumption.
- Limit caffeine intake as per Health Canada's recommendations.
- Refer patients with a history of kidney stones to a registered dietitian (RD) for nutrition counselling to ensure nutritional adequacy and appropriateness of the diet.

Introduction

The purpose of the Kidney Stones Nutrition Guideline is to provide health professionals with an overview of the evidence-based nutrition recommendations for adult and pediatric patients with kidney stones (nephrolithiasis) and provide answers to commonly asked questions (refer to Key Questions List).

Following the recommendations in the Nutrition Guideline (NG) can help to:

- Decrease the risk of subsequent stone formation and growth in those with a history of stones or significant risk factors for first-time stone formation.
- Alter the urine composition of constituents to decrease the risk of stone formation.

Note: For purposes of this NG, the single term patient will be used to refer to clients, patients, and residents.

Background

The Nutrition Guideline was developed by registered dietitians (RD) practicing in the area of kidney stones and is based on scientific evidence and best practice. It was reviewed by health professionals across the province. If you have questions about this NG, please contact Nutrition_Resources@ahs.ca.

Key Questions List

Key nutrition questions related to kidney stones that are addressed in this NG are listed below.

Types of Kidney Stones

- How do kidney stones form? What are the different types of kidney stones and how common are they?

Risk Factors for Kidney Stones

- What are the risk factors for kidney stones?
- How do diabetes, metabolic syndrome and body weight affect kidney stone formation?

Fluid Recommendations

- How does fluid intake affect kidney stone development and how much fluid is recommended for those with a history of kidney stones?
- What are effective strategies to help achieve high fluid intake?
- What dietary factors affect urinary pH?

Sodium Recommendations

- Is a sodium restriction recommended for individuals with a history of kidney stones?
- What amount of sodium is recommended if a sodium restriction is required?

Protein Recommendations

- What are the protein needs of individuals with a history of kidney stones?

Oxalate Restriction

- Is an oxalate-restricted dietary pattern recommended for individuals with a history of calcium oxalate kidney stones?
- How is an oxalate-restricted dietary pattern implemented?

Vitamin and Mineral Recommendations

- How does calcium intake affect kidney stone formation?
- How much calcium is recommended for individuals with a history of calcium-based kidney stones?
- What are the recommended sources of calcium for individuals with a history of calcium-based kidney stones?
- What other vitamins might be of concern in an individual with a history of kidney stones?

Additional Recommendations

- How can 24-hour urine measurements be used to guide nutrition care?
- Are there any specific beverages recommended to prevent recurring kidney stones for individuals with a history of kidney stones?
- Do individuals with a history of kidney stones need to avoid alcohol?
- Do individuals with a history of kidney stones need to limit purines?
- Does caffeine need to be limited for individuals with a history of kidney stones?
- Is there a dietary pattern that reduces kidney stone recurrence?

Considerations

- What are other important considerations for patients with kidney stones?

Resources

- When might a referral to a dietitian be recommended?
- Are there additional resources available for patients on nutrition recommendations for kidney stones?
- Are there additional resources available for health professionals providing care for patients with kidney stones?

Answers to Key Questions

Types of Kidney Stones

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How do kidney stones form? What are the different types of kidney stones and how common are they?

Kidney stones form through a process of crystallization that is influenced by the combination of the concentration of relevant compounds in the urine and the environment of the urine.

Approximately 90% of all kidney stones are calcium-based. Calcium oxalate stones are the most common type of stone and comprise approximately 70 to 80% of all stones followed by calcium phosphate (8–18%), uric acid (9–17%), struvite (2–4%), and cystine (0.1%) in adults.[1–3] Over the last 25 years, the incidence of kidney stones has increased in Canada with an estimated 12% of males and 6% of females developing a kidney stone at some point in their life.[4] Although pediatric stone disease is uncommon, its overall incidence is also increasing.[5]

Risk Factors for Kidney Stones

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What are the risk factors for kidney stones?

Nutritional intake is a risk factor for the development of kidney stones, either as a single cause or in conjunction with environmental/genetic factors.[6] Table 1 provides examples of specific urinary risk factors.

A family history of nephrolithiasis (kidney stones) also puts one at a 2.5 times higher risk for stone formation.[7] This may be due to a genetic predisposition as well as similar environmental factors, including diet.[7] Other medical conditions such as primary hyperparathyroidism, Crohn's disease, gout, diabetes, and renal tubular acidosis all increase the risk of calcium-containing stones.[7,8]

Table 1. Specific Risk Factors by Stone Type

Type of Stone	Risk Factors
Calcium oxalate	• Low urine volume (less than 2 L/day), hypercalciuria (high urinary calcium), hyperoxaluria (high urinary oxalate), hyperuricosuria (high urinary urea), hypocitraturia (low urinary citrate), and hypomagnesuria (low urinary magnesium).[9]
Calcium phosphate	• Low urine volume (less than 2 L/day), hyperphosphaturia (high urinary phosphate), hypocitraturia (low urinary citrate), hypercalciuria (high urinary calcium), and excessively alkaline urinary pH (greater than 7.0).[9]

Type of Stone	Risk Factors
Cystine	• Cysteine stones occur with cystinuria is an autosomal recessive genetic condition leading to hypercystinuria and stone formation due to the low solubility of cystine at low urinary pH.[10] • Low urine volume (less than 3 L/day), hypercystinuria (high urinary cystine), excessively acidic urinary pH (less than 5.5).[2]
Struvite	• Struvite stones (magnesium ammonium phosphate) occur with chronic urinary tract infections that produce bacterial urease (an enzyme that splits/cleaves urea to ammonia and CO2. When ammonia production is increased, urine becomes more alkaline elevating urinary pH (typically greater than 7.0).[11] • Low urine volume (less than 2 L/day).
Uric acid	• Low urine volume (greater than 2 L/day), hyperuricosuria (high urinary uric acid), excessively acidic urinary pH (less than 5.5).[1,9]

How do diabetes, metabolic syndrome and body weight affect kidney stone formation?

Diabetes and Metabolic Syndrome

A diagnosis of metabolic syndrome has been associated with a higher prevalence of kidney stones.[12] Similarly, three large cohort studies have shown that diabetes increases the risk of developing kidney stones in both men and women, however, the effect is more pronounced in women.[8] Both conditions are presumed to result in abnormal, excessive acidification of the urine predisposing to both urate and calcium-oxalate kidney stones.

For more information on diabetes please refer to the following NG: Adult Diabetes.

Body Weight

Kidney stones can occur at any body weight however, observational studies propose weight gain and greater adiposity (assessed by waist circumference, weight, weight gain and incremental increases in BMI) increases the risk of developing kidney stones in healthy individuals.[13] The effect appears to be greater in women than men (when comparing individuals with BMI 21–23 kg/m^2 to individuals with BMI ≥30 kg/m^2 had an increased relative risk (RR) of kidney stone formation with RR 1.33 for men, RR 1.90 for older women, and RR 2.09 for younger women.[14]

Large-scale observational studies have linked obesity (BMI >30 kg/m^2) with low urinary pH and uric acid stones, specifically.[15] The cause of this is suspected to be a higher BMI (BMI >30 kg/m^2) (and/or reduction in insulin sensitivity), combined with hyperinsulinemia, as seen in diabetes and metabolic syndrome, which contribute to uric acid stone formation.[12,13] A renal insulin-resistant state may explain the excretion of abnormally acidic urine with these conditions, leading to increased uric acid stone formation. Urine pH may be linked to BMI as well.[13] One study of more than 4500 adults showed urine pH values fall as body weight/BMI increased.[16]

Further research is required to determine if weight reduction decreases stone risk in individuals with excess weight.[6] It is also important to consider that some obesity treatment options (e.g. lipase inhibitors, ketogenic diets) may increase the risk of kidney stone formation by exacerbating the urinary pH.[17] For more information on obesity treatment options refer to the following NG: Adult Obesity Care.

The role body weight plays in the development of pediatric stone disease remains unclear. Assessment of anthropometric measurements is recommended.[18]

Fluid Recommendations

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How does fluid intake affect kidney stone development and how much fluid is recommended for those with a history of kidney stones?

Achieving dilution of the urinary compounds that form kidney stones through adequate fluid intake may be more important than any other nutrition intervention targeted to prevent future kidney stones.[19]

Low urine volume due to inadequate oral intake or excessive losses (e.g. excessive sweating, gastrointestinal fluid losses) are thought to result in supersaturation of the urine with solutes such as uric acid, calcium oxalate, and phosphate, leading to stone formation.[11,20,21] For most individuals, when urine output is greater than 2.5 L per day, the super-saturation for constituents like uric acid, calcium oxalate, and phosphate will not occur.[20]

In general, it is recommended all individuals with a history of kidney stones aim for a daily urine output of 2.5 L (see Table 2).[5] For pediatric patients with kidney stones increased fluid requirements are recommended irrespective of stone type and are made in proportion to body size.[22]

Table 2. Fluid Recommendations Based on Stone Type[5,9,20,23,24]

Type of Stone	Fluid Intake/day	Urine Output Target
Calcium oxalate Calcium phosphate Uric acid Struvite	• Greater than 2.5 L (2500 mL), may require 3L/day[6]	• greater than 2.5 L
Cystine	• Greater than 3–3.5 L (3000–3500 mL) • Achieving a high urine output is a critical component of stone prevention for individuals with cystinuria.	• greater than 3 L

What are effective strategies to help achieve high fluid needs?

Strategies that may assist individuals in achieving high fluid needs include:[5,6,20,25,26]

- Self-monitoring of 24-hour urine volume, fluid intake, and urine colour. Individuals may benefit from the use of mobile phone applications to assist with tracking.
- Self-monitoring of voiding frequency. For example, as normal bladder capacity in adults is approximately 300–400 mL, to produce 2.5L urine individuals need to pass urine 7–8 times/day.
- Not waiting until they are thirsty to drink.
- Drinking fluid after voiding.
- Increasing fluid intake to account for increased physical activity, sweating, travel, dry or hot weather.

What dietary factors affect urinary pH?

Supersaturation studies from kidney stone patients confirm that a low (acidic) urinary pH creates an environment more favourable for the formation of calcium oxalate, uric acid, and cystine stones whereas a high (alkaline) urinary pH creates an environment more favourable for calcium phosphate and struvite stones.[6,20]

Nutrition and medical management to prevent recurring kidney stones aim to alter the urinary pH, thereby increasing the solubility of the predominant stone compounds.[6] Advice regarding acidifying the urine may be effective in the prevention of calcium phosphate and struvite stones.[2] In the case of preventing calcium oxalate, cystine, and uric acid stones, interventions aimed at alkalinizing the urine may be effective (see Table 3).[2] When nutrition strategies are insufficient, pharmacological interventions can be undertaken under the supervision of a physician.

Table 3. Urinary pH and Nutrition Considerations

Urine pH	Goal	Types of Stones	Nutrition Considerations
Too acidic	Increase urinary pH/alkalinize	• Calcium oxalate • Uric acid • Cystine	• Dietary patterns high in acid-producing foods such as animal proteins, dairy products and grains can reduce urine pH.[2] • Reduce the acid load by increasing the intake of fruits and vegetables and limiting the intake of animal (flesh) protein (meat, fish, poultry), cheese and grains.[6,24]
Too alkaline	Decrease urinary pH/acidify	• Calcium phosphate • Struvite	• Increased intake of acid-producing foods such as animal (flesh) protein is not recommended and may result in adverse effects such as increasing the risk of certain types of stones, such as cystine and uric acid stones and other health concerns.[2]

Urine pH	Goal	Types of Stones	Nutrition Considerations
			• Cranberry juice/cranberry concentrate tablets have been suggested as a method to acidify the urine without the adverse effects of other acid-producing foods. However, studies have shown mixed results, with no long-term data, small sample sizes, and ultimately, no associations between increased intake of cranberry juice/cranberry concentrate tablets to acidy the urine and a reduction in kidney stones.[27–30]

Careful consideration of the patient's health condition(s) and risk factors, type of stone (based on stone/calculus analysis/spectroscopy), urine pH, 24-hour urine volume, and 24-hour urinary citrate level should be given before providing any dietary advice to acidify or alkalinize the urine. Referral to an RD is recommended to support patients with strategies to address the urine pH and review other aspects of intake, including dietary changes to affect risk factors of certain types of stones.

Sodium Recommendations

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Is a sodium restriction recommended for individuals with a history of kidney stones?

High salt (sodium chloride) intake is associated with increased excretion of urinary calcium, a risk factor for calcium-based stones. A high salt intake also decreases urinary citrate concentration, another risk factor for stone formation.[5]

It is recommended patients requiring a sodium-restricted dietary pattern be referred to an RD for nutrition counselling. The RD can take into account other dietary factors and modifications that may be required. It is recommended patient education includes label reading for foods containing high amounts of sodium and reviewing nutrient content claims, low sodium alternatives, cooking methods, and appropriate serving sizes. Medications that include the word sodium in their formulaic nomenclature such as sodium bicarbonate do not appear to have the same effect on urinary calcium and citrate as sodium chloride.[13]

What amount of sodium is recommended if a sodium restriction is required?

The primary focus of a sodium-restricted dietary pattern is to limit the intake of high-sodium foods. This includes limiting intake of processed or prepared foods and preparing food using ingredients with little to no added sodium.[31]

Table 4. Recommended Sodium Recommendations

Population	Recommendations
Individuals with a history of stone formation or at risk for kidney stones	• Reduce sodium intake to ideally 1500 mg (65 mmol) per day not exceeding 2300 mg (100 mmol) per day.[5,6,24]
Adolescents	• Less than 2400 mg per day[32]
Children	• 2–3 mEq/kg/day[32]

For more information, refer to Sodium: Sodium and your health | Health Canada.

Protein Recommendations

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What are the protein needs of individuals with a history of kidney stones?

Dietary patterns high in animal protein have been associated with increased uric acid excretion, decreased urinary citrate, and lower pH levels which can predispose individuals to uric acid or calcium-oxalate nephrolithiasis.[5] While further research is required, dietary patterns with a higher animal-to-plant protein ratio have been associated with an increased risk of kidney disease.[33]

Encourage patients (adult and pediatric) with a history of kidney stones to meet, but not exceed the dietary reference intake/value (DRI) for protein.[13,34] DRI values for protein can be found at Dietary reference intakes | Health Canada

It is recommended patients requiring a protein-modified diet be referred to an RD for nutrition counselling. It is recommended patient education includes foods containing higher protein quality, protein type, appropriate serving sizes, and adequate energy (calorie) provisions.

Oxalate Restriction

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Is an oxalate-restricted dietary pattern recommended for individuals with a history of calcium oxalate kidney stones?

Oxalate is a compound found in some foods and is also produced as a waste product of metabolism. Dietary oxalate restriction should be considered in patients with documented high-normal or hyperoxaluria, and conditions which increase oxalate absorption and/or fat malabsorption.[13] For example, patients with inflammatory bowel disease or who have had gastric bypass surgery, specifically Roux-en-Y bypass, are prone to fat malabsorption. Fat malabsorption increases the colonic permeability to oxalate in addition calcium binds with fatty acids leaving more oxalate unbound and free for absorption.[35] This process increases the risk of stone formation.

A variety of mechanisms have been suggested to explain the variation in urinary oxalate levels among individuals. Individuals may have higher dietary oxalate intake, increased enteric absorption, increased bacterial synthesis, or reduced gastrointestinal breakdown of oxalate, leading to higher urinary oxalate levels and calcium oxalate stone formation.[36,37] At present, there is inadequate evidence to support dietary oxalate restriction as a preventative measure for stone formation in healthy adults. A dietary oxalate restriction is not recommended in otherwise healthy adults, without a history of calcium oxalate stones or elevated urinary oxalate level.[13]

How is an oxalate-restricted dietary pattern implemented?

Low oxalate/oxalate-restricted diet recommendations can vary. Often it is defined as limiting dietary oxalate to no more than 40 to 50 milligrams per day.[20] However, as there are non-nutritional factors that also influence hyperoxaluria, overly restrictive low-oxalate diets are not recommended.[38]

Several factors make it difficult to determine the exact oxalate content of food or the exact amount that an individual will absorb from an oxalate-containing meal/food:

- Only less than 10% of ingested oxalate is absorbed.[9] The absorption of oxalate is influenced by the amount and form of oxalate, the amount of calcium and magnesium in the meal, and the presence or absence of oxalate-degrading bacteria (such as *Oxalobactor formigenes*) in the gut.[39]
- Oxalate concentration data can be conflicting and inaccurate due to inter-laboratory variability and differing analytical techniques.[6]
- There are variations in oxalate levels based on the soil/location/environment in which the food is grown, the plant part being analyzed, methods of analysis used, and cooking methods (e.g. boiling reduces oxalate content more than other cooking methods).[39,40]

It is recommended patients requiring an oxalate restriction be referred to an RD for nutrition education on foods high in oxalates and where to find accurate information on sources of oxalates. There are many lists available on the oxalate content of foods with a lot of variation. The Harvard Food List is considered an accurate and up-to-date source. Individuals requiring an oxalate-restricted dietary pattern should be encouraged to avoid foods highest in oxalate as a first step instead of calculating the total oxalate content of all foods eaten.[39]

Examples of foods high in oxalates:[41]

- almonds
- baked potato with skin
- beets
- wheat bran and bran cereals
- spinach
- sweet potatoes
- quinoa

The total dietary calcium intake plays an important role in oxalate absorption. Increased dietary calcium results in decreased urinary oxalate excretion.[33] For individuals (adult and pediatric) requiring an oxalate restriction, care should be taken to ensure the DRI for calcium is also met. DRI values for calcium can be found at Dietary reference intakes | Health Canada.

Further research is required to examine the efficacy of oxalate restrictions on the recurrence of kidney stones.

Vitamin and Mineral Recommendations

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How does calcium intake affect kidney stone formation?

Calcium intake has an inverse association with kidney stone formation. In other words, higher dietary calcium intake leads to a lower risk of calcium-based kidney stones. Low calcium intake is associated with increased oxalate absorption and hyperoxaluria, risk factors for calcium-based stones as less calcium is available to bind oxalate in the intestinal lumen.[20]

Although calcium is present in most stones (greater than 80%), it is unclear if calcium, or other nutrients, independently or in combination with other nutrients, increase the risk of stone formation. It may be that individual physiology, or a combination of dietary and non-dietary factors, including the presence or absence of certain nutrients such as calcium, that influence stone formation.[42]

Additionally, calcium excretion is directly linked to dietary sodium intake, and low urine volume results in the supersaturation of urine. A recent study exploring the role of pharmacologic therapy in reducing urinary calcium levels and stone formation demonstrated that without the achievement of dietary sodium and fluid targets, urinary calcium levels do not fall.[43] Therefore, in addition to adequate calcium intake, sodium restriction and fluid liberalization play an important role in calcium-based kidney stone management.

How much calcium is recommended for individuals with a history of calcium-based kidney stones?

The recommended daily intake of calcium for adults with a history of calcium-based kidney stones is 1000–1200 mg meeting the DRI for calcium.[5,24] In pediatrics, it is also recommended to meet the DRI for calcium for age.[44] DRI values for calcium can be found at Dietary reference intakes | Health Canada.

What are the recommended sources of calcium for individuals with a history of calcium-based kidney stones?

Individuals with a history of calcium-based kidney stones should aim to obtain adequate calcium through dietary sources (see Table 5). It is recommended to include calcium-containing food with high oxalate-containing meals and snacks to help bind oxalates.[45]

Table 5. Dietary Sources of Calcium[46]

Category	Examples
Milk and milk alternatives	• Milk, yogurt, and cheese (considered a very high source of calcium/ serving) • Fortified plant-based beverages, however, oxalate content needs to be considered. A recent study showed almond and cashew milk have more potential stone risk factors.[47]
Dark green vegetables	• Chinese broccoli • Kale • Bok choy
Fish with soft bones	• Canned salmon or sardines

Calcium intake from supplements compared to calcium from dietary sources (both dairy and non-dairy) may have an impact on stone formation risk. Individuals with a history of kidney stones are at higher risk for stone formation when they receive their calcium intake from supplements rather than food.[42]

The differences between calcium-containing foods and calcium supplements have been attributed to:

- Ingestion of calcium supplements without food leads to increased calcium absorption and urinary excretion, with little or no effect on oxalate excretion/absorption.[42]
- The hypothesis is that dairy foods also contain specific components that inhibit stone formation.[33]
- Calcium supplementation may result in excessive total calcium intake (from food and supplements).[24]

Considerations if an individual chooses to use calcium supplement:

- Calcium supplements should only be used to bring total calcium intake to DRI levels.[6] It is important to consider the elemental calcium dose of the supplement versus the total calcium content. DRI values for calcium can be found at Dietary reference intakes | Health Canada
- Calcium supplements should be taken with meals so the calcium can bind with dietary oxalate to reduce intestinal absorption.[5]

- Avoid calcium supplements with added Vitamin D. A recent systematic review found vitamin D combined with calcium supplementation has been associated with an increase in the incidence of kidney stones in individuals who are post-menopausal with no history of kidney stones.[48]

What other vitamins might be of concern in an individual with a history of kidney stones?

Vitamin D Supplements

Generally, the effect of supplemental vitamin D use on individuals prone to stone formation remains unclear.[5,49] Considerations regarding supplemental vitamin D include:

- There are conflicting results from studies examining the association between serum vitamin D levels and urinary calcium excretion (a risk factor for kidney stones).[5]
- High doses of supplemental vitamin D have been associated with an increased risk of elevated urinary calcium excretion.[50]
- The largest study to date examining vitamin D intake and the risk of kidney stones found no statistically significant association.[51] However, a recent systematic review concluded there is an increased risk of kidney stones when vitamin D3 and calcium are provided as a combined supplement.[48]
- One study suggests that individuals taking 4000 IU vitamin D/day (tolerable upper intake level) in addition to calcium supplements or having a high dietary calcium intake should be monitored for the development of hypercalciuria (and hypercalcemia).[50]
- Vitamin D deficiency is known to be prevalent in stone formers, however, larger prospective studies are needed to establish the safety and efficacy of vitamin D therapy.[49]
- Vitamin D repletion among stone formers with inadequate vitamin D levels does not appear to increase urinary calcium excretion, though the long-term effects of vitamin D supplementation have not been studied in this population.[52]
- Health professionals should consider the risks of chronic low vitamin D levels when deciding whether to supplement. Recent Canadian Urology Association guidelines suggest supplementing vitamin D in calcium stone formers with vitamin D deficiency, however, monitoring of vitamin D levels and hypercalciuria is recommended.[5]

Vitamin C

Vitamin C intake has been hypothesized as a risk factor in kidney stone formation due to the hepatic conversion of excess vitamin C (ascorbic acid) to oxalate resulting in increased urinary oxalate excretion.[11] However, despite large-scale observational studies, there remains inconclusive evidence on the role of vitamin C and stone formation.[13]

Observational studies have found an association between vitamin C intake (from diet and supplements) and the risk of kidney stone formation in healthy men with no previous history of kidney stones.[53] This association has not been found in women.[54] However, it is difficult to assess the role of dietary vitamin C alone because studies to date have not excluded other nutrients, including nutrients that either present or absent, may have a protective effect on the development of kidney stones. For example, foods that contain both vitamin C and oxalate, which can both increase urinary oxalate, also contain nutrients such as citrate and potassium, which can inhibit the development of stones.[13] It is recommended that individuals at risk for the development of kidney stones should not limit their dietary intake of vitamin C.[13] Table 6 provides considerations for the use of vitamin C supplements.

Table 6. Vitamin C Supplementation Considerations

Population	Considerations
Individuals with a history of kidney stones (especially calcium oxalate stones and individuals with hyperuricosuria)	• Urinary oxalate is increased with vitamin C supplementation of greater than 1000 mg per day.[5] • If taken, vitamin C supplementation of more than 1000 mg per day is not recommended.[5]
General population, no history of kidney stones	• Vitamin C supplementation beyond the upper limit (UL) of 2000 mg vitamin C per day is not recommended.[13]
Pediatrics	• Vitamin C supplementation should be limited.[44]

Additional Recommendations

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How can 24-hour urine measurements be used to guide nutrition care?

Reviewing 24-hour urine measurements can assist in targeted medical management and nutrition interventions for individuals with kidney stones. In general, it is recommended that 24-hour urinary measurements be obtained in all patients with recurrent kidney stones and in motivated patients who have only ever formed one stone. Sequential 24-hour urinary studies can inform patient and provider discussions regarding adherence to pharmacological and nutrition recommendations over time and potential next steps. Table 7 provides examples of nutrition interventions based on 24-hour urine measurements.

Table 7. Examples of Urinary Risk Factors and Nutrition Interventions[6,55]

Urine Test	Urinary Risk Factor	Goal to Address 'Suspected Cause'	Possible Interventions
24-hour urine	Low urine volume (less than 2L/day)	• Promote increased urine volume to lower urine supersaturation	• Refer to question How does fluid intake affect kidney stone development and how much fluid is recommended for those with a history of kidney stones? • Increase fluid intake
Urinalysis (random)	pH	• pH less than 5.5 favours precipitation of calcium oxalate, uric acid and cystine crystals • pH greater than 6.6 favours precipitation of calcium phosphate crystals	• Refer to question What dietary factors affect urinary pH?
Calcium, 24-hour urine	Hypercalciuria (greater than 7.5 mmol)/24-hours)	• Promote renal calcium absorption	• Reduce sodium intake
		• Normal (increase) bone retention if suboptimal	• If high, reduce caffeine and alcohol intake • Ensure appropriate calcium and vitamin D intake
Oxalate, 24-hour urine	Hyperoxaluria (Greater than 450 µmol/24-hours) Consider intervention if level greater than 350 µmol/24-hours)	• Enhance gastrointestinal binding potential of oxalate	• Increase calcium intake with meals • Reduce intake of high oxalate foods
		• Normalize (reduce) oxalate absorption	• Consider fat malabsorption • Increase intake of high calcium foods with meals
		• Reduce oxalate biosynthesis	• Discontinue vitamin C supplements
Urate, 24-hour urine	Hyperuricosuria (Greater than 4.5 mmol/24-hours)	• Reduce uric acid biosynthesis	• Reduce intake of high purine foods
		• Reduce uric acid precipitation potential	• Reduce dietary PRAL (potential renal acid load) (e.g. reducing animal (flesh) protein)

Urine Test	Urinary Risk Factor	Goal to Address 'Suspected Cause'	Possible Interventions
Citrate, 24-hour urine	Hypocitraturia (less than 1 mmol/ 24-hours) As per best practice, ideal 2.5–3.0 mmol/ 24 hours	• Reduce renal citrate reabsorption (increase excretion)	• Reduce dietary PRAL (potential renal acid load) (e.g. reducing animal [flesh] protein) • Increase dietary citrate (e.g. increasing fruit and vegetable intake)
Sodium, 24-hour urine	High urinary sodium (greater than 100 mmol/24 hours)	• Reduce urinary calcium excretion	• Reduce sodium intake

Note: The urinary risk factor ranges are in reference to adult ranges.

Are there any specific beverages recommended to prevent recurring kidney stones for individuals with a history of kidney stones?

There is a lack of consensus and limited evidence to support specific beverages in the prevention of kidney stones (see Table 8).[21]

Table 8. Beverages and their Effect on Kidney Stones

Beverage	Evidence
Sugar-sweetened beverages	• Sugar-sweetened beverages, particularly those sweetened with fructose, have been found to be independently associated with an increased risk of kidney stones in observational trials.[56] However, these types of beverages have not been evaluated in randomized trials.[24] • The consumption of sugar-sweetened beverages and foods with added sugar should be limited as recommended by Canada's Dietary Guidelines.[31,57]
Milk	• Does not increase the risk of kidney stones unless consumed in excess.[5]
Lemon juice	• Lemon juice contains a high concentration of citrate and is thought to enhance urinary citrate excretion. Limited evidence suggests adding lemon juice to water may reduce urinary calcium and pH although the quality of evidence is very low to low.[58] • Patients interested in increasing their dietary citrate are encouraged to speak with an RD or care team member for further guidance.
Lemonade/cranberry juice	• Hypothesized to act as an alkalizing agent. Lack of evidence on the risk or benefit of consumption.[21]

Beverage	Evidence
Orange juice	• Hypothesized to act as an alkalizing agent, however, evidence is inclusive.[19] • Due to the high sugar (fructose) and calorie content of fruit juice, intake could offset benefits. Whole fruit consumption and drinking fruit juice in moderation are recommended.[6]
Apple cider vinegar	• Hypothesized to act as an alkalizing agent, however, the alkali content on a per-serving basis is minimal. It is unlikely individuals would be able to consume quantities to match pharmacological interventions.[59]
Water type	• Different types of water may have differing effects on stone formation, but there is inconclusive evidence to support any specific type being superior in terms of preventing stone development. All types of water are considered effective (e.g. filtered versus non-filtered [including well water], hard versus soft, carbonated).[9,60,61]

Do individuals with a history of kidney stones need to avoid alcohol?

Observational studies have shown that moderate consumption of wine and beer may be associated with reduced kidney stone formation. It is hypothesized this may be due to its effect on antidiuretic hormone (ADH) resulting in urine dilution.[57] However, there are no recommendations on specific amounts of alcoholic beverages to reduce the risk of kidney stones and the protective benefit must be weighed against the risk of other health consequences.[5,33]

It is recommended individuals with a history of kidney stones follow Canada's Guidance on Alcohol and Health (2023) recommendations.[62]

- One drink is considered: 341 mL (12 oz) beer/cooler/cider, 142 mL (5 oz) wine, 43 mL (1.5 oz) distilled alcohol such as rye, gin, rum, etc.

Alcohol has also been suggested to contribute to increased uric acid production and delayed excretion of uric acid through the kidneys.[63] Beer, in particular, contains purines which are catabolized into uric acid and therefore may contribute to increased uric acid stone formation.

Do individuals with a history of kidney stones need to limit purines?

Purines are substances found in some foods that break down into uric acid in the body. Although evidence is limited, guidelines suggest purines should be limited for individuals with recurrent calcium-based or uric acid stones.[5,45,64] Animal protein provides a source of purines, which contributes to high urinary acid levels and lowers urinary pH promoting uric acid and calcium oxalate stone formation.[45]

Little is known about the precise quantity of individual purines in most foods, especially when the cooking or processing techniques are considered.[40,65] Observational data has shown that a strict purine-free diet will decrease serum urate by about 15–20%; however, there is no data to indicate how much a purine-free diet would impact (reduce) urinary uric acid levels. The rigidity of a purine-free diet greatly impacts long-term compliance; therefore, moderation of high-purine foods is likely a more realistic approach.[65] The bioavailability of purine is also known to vary substantially.

Examples of foods high in purines:[6]

- Beer
- Gravies and sauces made from meat, meat extracts (Bovril®, Oxo®)
- Anchovies, sardines, herring, mussels, tuna, codfish, scallops, trout, and haddock; bacon; organ meats (such as liver or kidney); tripe; sweetbreads; wild game (such as deer or goose)
- Yeast and yeast extracts (taken as supplements)

High-purine vegetables are not considered significant to uric acid biosynthesis, and therefore need not be restricted.[6,66] In addition, dairy, fats, oils, and fruits are considered low in purine and do not need to be restricted.[67]

Patients requiring a purine-modified dietary pattern should be referred to an RD for nutrition assessment and counselling. Specific nutrition education by an RD is essential for balancing a purine restriction along with other dietary restrictions/limitations and overall nutritional adequacy. Without careful nutrition education and specific strategies, the patient could be at risk for inadequate intake and/or protein-energy malnutrition.

Does caffeine need to be limited for individuals with a history of kidney stones?

Caffeine causes increased urinary flow (diuresis) through action on both the proximal and distal tubules of the nephron and decreases the maximal concentrating ability of the kidneys (natriuresis).[68] In an eight-year follow-up study of the Nurses' Health and Health Professionals' studies, a reduction of the risk of kidney stone formation was observed with the consumption of coffee, decaffeinated coffee, and tea (≥1 cup/day) in previously healthy individuals with no history of stones. It is unclear if there is another constituent of these beverages that may hinder stone formation, as the effect was seen in decaffeinated beverages as well.[68]

The effect of caffeine consumption on those with a history of kidney stones also remains unclear and has not been well studied. As per best practice, individuals with a history of stone formation should follow current recommendations from Health Canada for caffeine consumption. Health Canada recommends the following maximum daily limits for caffeine:[69]

- For individuals who are planning to become pregnant no more than 300 milligrams per day
- For adults (18 years or older): no more than 400 milligrams per day
- For children and adolescents (up to 18 years) no more than 2.5 milligrams per kg of body weight

For more information on quantities of caffeine in particular beverages, refer to Caffeine in foods | Health Canada

Is there a dietary pattern that reduces kidney stone recurrence?

To date, there are few studies examining specific dietary patterns and the incidence of kidney stones.

Analysis of data from several large observational studies has shown a Dietary Approaches to Stop Hypertension (DASH)-style diet resulted in the lowest risk for kidney stones.[70] The DASH diet recommends a sodium reduction and includes foods that are rich sources of specific minerals including calcium, potassium, and magnesium.[71,72] It is unclear, at this time, what aspects of the DASH-style diet have an impact on the risk of developing kidney stones.

A recent prospective cohort study analyzed the association between the Mediterranean dietary pattern and the risk of kidney stones and found adherence to the diet was associated with a lower risk of developing kidney stones.[73] One limitation of the study was that kidney stone type was not analyzed. Further research on dietary patterns to reduce the incidence of kidney stones is required.

For more information on the DASH and Mediterranean diet refer to the NG: Hypertension.

Considerations

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Household Food Insecurity

Household food insecurity (HFI) is defined as "an inadequate or insecure access to food because of financial constraints";[74] it impacts physical, mental and social well-being. Health professionals will encounter patients living in food-insecure households, due to the high prevalence of HFI among those accessing health care.[75]

Recent studies have found an association between food insecurity and the likelihood of kidney stones and stone reoccurrence.[76,77]

HFI is best addressed through income-based interventions.[74,78,79] Those experiencing HFI have food preparation, budgeting, and cooking skills similar to the general population.[80] Interventions focused on food skills do not protect people from, nor improve HFI.[80] Emergency food programs (e.g. food banks) may provide temporary relief.[81] However, these programs do not solve HFI and are inappropriate and/or inaccessible for many patients.[81]

Health professionals can offer better support if they are aware when patients are worried about having enough money for food and are experiencing other challenges because of financial strain.[82,83] Health professionals are encouraged to work with patients to develop interventions that are sensitive to financial strain.

Key steps for health professionals include:

- Learn about financial strain, how to screen patients for poverty, and the link between poverty and poorer health through the **Identifying Financial Strain and Addressing Financial Barriers to Health Care Modules**; available on MyLearningLink for AHS staff and on CLiC for Covenant Health staff.
- Review the NG: Household Food Insecurity for additional information on how to support patients experiencing HFI.
- Assist patients in accessing available income supports. The provincial directory 211 (ab.211.ca) can be used to identify financial benefits, programs, and services.

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When might a referral to a dietitian be recommended?

RDs play an important role in the management of kidney stones and can provide tailored nutrition interventions through medical nutrition therapy. Adherence to nutrition and fluid recommendations has been shown to reduce stone recurrence rates and may be beneficial even for first-time stone formers.[5]

Individuals who are at high risk of malnutrition, with recurrent (or multiple) kidney stones, complex medical situations or who require assistance implementing nutrition recommendations should be referred to an RD:[5]

- Visit ahs.ca/NutritionWorkshops for virtual workshops and classes available.
- Visit the Alberta Referral Directory and search for nutrition counselling.
- To learn more about programs and services offered in your zone, visit ahs.ca/Nutrition.
- Health Link has registered dietitians available to answer general nutrition questions. If a patient has a nutrition question, they can complete a self-referral at ahs.ca/811 or call 811 and ask to talk to a dietitian.

Are there additional resources available for patients on nutrition recommendations for kidney stones?

- Nutrition handouts are available for patients on a variety of topics to help support their learning needs and nutrition goals. Visit ahs.ca/NutritionHandouts for more information.
- Kidney Foundation of Canada has information for patients with kidney stones.
- Davita has general information about kidney stones, treatment options, treatment options and renal recipes.

Are there additional resources available for health professionals providing care for patients with kidney stones?

- The Kidney Stone Pathway has resources available for patients to manage and treat kidney stones. There are also resources for primary care providers to aid in the diagnosis, medical management, and referral of adults with kidney stones. Available at: Alberta's Pathway Hub | Alberta Health Services and Clinical Pathways & specialty and access | Specialist Link.
- Nutrition guidelines are available on a variety of topics to help support health professionals provide consistent, evidence-based messaging. Visit ahs.ca/NutritionGuidelinesHP for more information.

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