CARI GUIDELINES
CARING FOR AUSTRALIANS & NEW ZEALANDERS WITH KIDNEY IMPAIRMENT

Nutrition therapy for the prevention of kidney stones

Version 11
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GUIDELINE RECOMMENDATIONS

Practice Points

- Nutrition therapy for kidney stone prevention should be centred around a healthy eating pattern and whole foods that promotes overall health and quality of life, as detailed in the Heathy Eating Guidelines for Australian and New Zealand adults (1, 2).
- Strategies to achieve a healthy body weight will help to reduce the risk of stone recurrence.
- Dietitians experienced in kidney stone prevention should be part of the multidisciplinary care team for people with recurrent kidney stones.

DRAFT

Fluid intake

a. **We recommend optimising fluid intake to achieve a daily urine output of greater than or equal to 2.5 litres in all people with kidney stones.**
(Strong recommendation, moderate certainty of the evidence)

Practice Points

- High fluid intake dilutes the urine and is the most important factor to prevent kidney stones.
- An individualised approach is necessary to guide fluid intake. Factors such as extra-renal losses, exercise, environment and co-morbidities should be taken into consideration. People with kidney stones who are at risk of volume overload require careful tailoring of advice to prevent fluid imbalance and electrolyte disorders.
- All fluids contribute to meeting fluid requirements, with water being the most beneficial, while sugar-sweetened beverages such as soft drinks are associated with a higher stone risk and should be discouraged.

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- Guidance on timing of fluid should encourage an even distribution throughout the day. Support using app-based technology and smart beverage bottles may be helpful.
- People with cystine stones should aim for a daily urine output of greater than 3 litres.

Sodium intake

b. We recommend a daily sodium intake of less than 100 mmol (2300 mg) in people with calcium-based stones.
(Strong recommendation, low certainty of the evidence)

Practice Points

- A reduced sodium intake and choosing foods low in sodium are key to a healthy eating pattern. Most of the sodium in food is found in processed foods, with only approximately 10-20% from discretionary salt.
- A low-sodium diet can be difficult to achieve due to over-reliance on processed foods which are often cheaper, more available, and require little preparation.
- The potential of thiazide diuretics to reduce urinary calcium is enhanced when combined with a reduction in dietary sodium.
- 24-hour urine sodium is a good estimate of total sodium intake.

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Calcium and oxalate intake

c. We recommend achieving the recommended dietary intake for calcium (1000 mg for adults <70 years of age) in people with calcium stones, especially in those with high urine oxalate.
(Strong recommendation, moderate certainty of the evidence)

d. We recommend against a low oxalate diet for the management of calcium oxalate stones.
(Strong recommendation, very low certainty of the evidence)

Practice Points

- For adults ≥70 years of age the recommended dietary intake for calcium is 1300 mg.

GUIDELINE RECOMMENDATIONS

- A low calcium diet leads to increased absorption and urinary excretion of oxalate, resulting in oxaluria, has no effect on decreasing kidney stone recurrence, and may decrease bone density.
- Oxalate is present in a wide variety of foods, including many healthy foods, and it is difficult to reduce significantly while maintaining a balanced diet.
- Where there is high urinary oxalate, calcium fortification at mealtimes is recommended to reduce oxalate bioavailability. Include high calcium foods such as milk, yogurt, cheese or calcium fortified non-diary alternatives.
- Calcium supplements may be considered to achieve recommended daily calcium intake and should be taken at mealtimes to achieve beneficial binding of oxalate.
- Enteric hyperoxaluria due to malabsorption requires a tailored approach. Calcium supplementation, limiting high oxalate if consumed excessively and/or frequently without a calcium source, and/or a low-fat diet may be required.
- Magnesium can also bind oxalate and reduce oxalate absorption. Magnesium supplementation may be beneficial if urine magnesium is low. Diarrhoea may limit tolerance and dosing.
- Limit vitamin C intake from supplements, i.e., doses exceeding 500mg per day.
- Vitamin D within recommended dietary intake is not associated with increased risk of kidney stones.

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Fruit, vegetables, and animal protein intake

e. We recommend a diet rich in fruits and vegetables, limiting intake of non-dairy animal protein.
(Strong recommendation, low certainty of the evidence)

Practice Points

- Healthy eating guidelines suggest at least two serves of fruit and at least five serves of vegetables daily.
- High intake of non-dairy animal protein is associated with an increased risk of stones. We recommend a moderate protein intake within the Australia and New Zealand Healthy Eating Guidelines.
- Dairy protein intake is associated with a reduced risk of stone formation and vegetable protein sources are not known to influence stones risk.

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- Uncertainty exists around stone risks associated with protein supplements such as whey isolates and creatine supplementation, thus their safety cannot be assured in people with kidney stones.
- Potassium citrate supplementation may be required, in addition to enhanced intake of fruit and vegetables, to achieve alkalinisation of the urine and increase urinary citrate levels.

Scope of the guidelines

These guidelines deal with nutrition-focused prevention of kidney stones in adults. Other clinical practice guidelines should guide nutrition-focused prevention of kidney stones in children.

Background

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Nutrition therapy is well established in clinical practice as a central strategy for reduction of kidney stone recurrence. High quality evidence is limited by confounding, a focus on single nutrients rather than dietary patterns, lack of specificity and multiple approaches being assessed simultaneously. The inclusion of registered Dietitians in the management of people with recurrent kidney stones is recommended in Nephrology and Urology guidelines (3, 4). Retrospective studies of nutrition counselling demonstrate a decrease in markers of kidney stone formation (5) and decreased rates of stone recurrence (6, 7).

The lack of evidence clarity poses a challenge for nutrition therapy guidance. To better understand the perspective of people with kidney stones, CARI Guidelines conducted two workshops, further referred to as “CARI Kidney Stones Consumer Workshops”, with 28 people with kidney stones in two locations in New Zealand: Auckland provided a sample in a metro area and Whangarei, in Northland, provided a sample from a regional/rural area. Participants unanimously reported inconsistent and confusing nutrition information. There was a strong indication that clear, consistent, tailored nutrition education and management strategies were needed for self-management of recurrent kidney stones.

Implementation and audit

Dietitians within a multidisciplinary team including a nephrologist with expertise in kidney stone management are central for the implementation of these guidelines. Dietitians provide nutrition therapy, including a thorough assessment of an individual’s dietary intake, to identify nutrition contributors for kidney stone formation. These may include inadequate fluid intake, excessive sodium intake, excessive animal protein intake, low fruit and vegetable intake, pr inadequate calcium intake. Additionally, dietitians conduct 24-hour urinalysis to identify urine

risk factors, which inform tailored nutrition recommendations to reduce kidney stone recurrence. Dietitians re-assess an individual's progress with nutrition interventions utilising repeat 24-hour urinalysis to evaluate urine composition changes and adjust nutrition therapy accordingly.

Nutrition therapy is the primary self-management strategy for reducing kidney stone recurrence and was highly desired by the participants at the CARI kidney stones consumer workshops:

> *"[the dietitian] was a godsend, because she gave me a whole lot of information so that I could help myself. I could read easily what was good for me and what wasn't. So now, there's a whole list of things that I do eat and a whole lot of things that I don't eat. I'm careful about my salt. I drink a lot of water..." (Female, 60-69 years old, Whangārei)*

Access to a dietitian experienced in kidney stone prevention is limited in Australia and New Zealand, particularly in rural and remote locations. However, the involvement of dietitians in the management of individuals with recurrent kidney stones is an indicator of high-quality clinical care.

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Guideline recommendations

Practice Points

- **Nutrition therapy for kidney stone prevention should be centred around a healthy eating pattern and whole foods that promotes overall health and quality of life, as detailed in the Heathy Eating Guidelines for Australian and New Zealand adults (1, 2).**

- **Strategies to achieve a healthy body weight will help to reduce the risk of stone recurrence.**

Rationale

Higher body mass index (BMI) has been demonstrated to be a risk factor for kidney stone recurrence, with a pooled odds ratio of 1.045 (95% CI 1.008, 1.083) from 16 studies (*n* = 22,087) (8). Obesity has been demonstrated to increase the adjusted odds of kidney stones by almost 300% (9). Higher BMI has also demonstrated an association with increased urine oxalate and phosphate, and lower urine pH and citrate (10).

- **Dietitians experienced in kidney stone prevention should be part of the multidisciplinary care team for people with recurrent kidney stones.**

Rationale

Improved diet quality has been associated with a lower risk of kidney stones (11). The cross-sectional National Health and Nutrition Examination Surveys have evaluated the nutritional status of 30 068 adults in the United States of America from 2007 to 2018. The study has demonstrated that better diet quality, measured as a higher score on the Healthy Eating Index, was associated with decreased risk of kidney stones. This was identified through self-reporting after adjusting for age, sex, ethnicity, deprivation, BMI, physical activity, smoking, alcohol intake, and self-reported comorbidities. Typical dietary patterns in high-income countries including Australia and New Zealand are characterised by high consumption of processed foods (high in sodium and sugar), high animal protein, and low consumption of fruits and vegetables. This may increase the risk of kidney stones by lowering urine pH, and increasing urine calcium and oxalate (12). A healthy diet which incorporates all food groups and aligns with the Australian and New Zealand Healthy Eating Guidelines is encouraged (1, 2) (Figure 1).

The CARI Guidelines consumer workshop participants highlighted concerns about overly restrictive diets resulting in the exclusion of healthy foods due to an approach focusing on nutrients rather than whole foods:

> *"You follow all these different diets, I'm concerned about the dietary requests, cutting out so many healthy vegetables, et cetera, out of the diet. I have a big question mark about that."* (Female, 60-69 years old, Auckland)

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People with recurrent kidney stones may receive nutrition advice from several health professionals, often supplemented with self-directed consultation of online resources. This information may be outdated, inaccurate and conflicting leading to confusion and frustration (13, 14). Encouraging a wholefoods and healthy eating pattern is more likely to support sustained and achievable kidney stone risk reduction and improved quality of life. Healthy dietary patterns such as the Dietary Approaches to Stop Hypertension (DASH) diet have been found to be associated with decreased kidney stones in observational studies (15, 16).

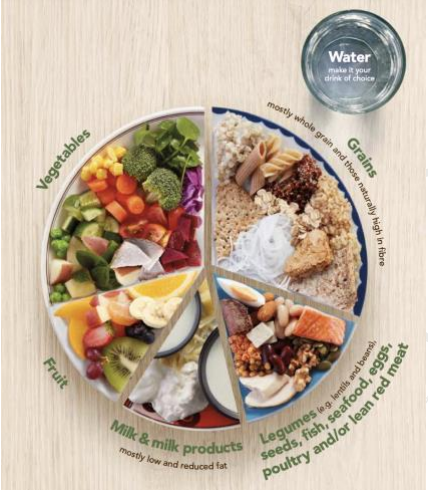


Figure 1. Whole Food Wheel from the New Zealand Government Eating and Activity Guidelines (1).

Fluid intake

a. We recommend optimising fluid intake to achieve a daily urine output of greater than or equal to 2.5 litres in all people with kidney stones.

(Strong recommendation, moderate certainty of the evidence)

Rationale

Both randomised control trials (17-19) and observational studies (20) have found that increased fluid intake (>2.0 L/d) reduces stone recurrence in people with kidney stones with very few adverse effects. The protective effect of a generous fluid intake was demonstrated in 199 people with idiopathic calcium oxalate stones, randomised to either high fluid intake (sufficient to produce >2 L urine daily) compared to control. Over a five year study period, the risk of stone recurrence was less than half in the high fluid group compared to controls (18).

Several prospective cohort studies show the beneficial effect of fluid intake on stone risk. In the Nurses' Health Study (21), in 245 nurses, there was a 32-39% lower incidence of symptomatic stones in the highest (>2.5 litres) compared to the lowest quartile of fluid intake. In a prospective cohort study of more than 50,000 male health professionals similar trends were seen over a 15 year period, with a 29% reduction in kidney stones for the highest quintile compared to the lowest for fluid intake (22). Total fluid intake was associated with a reduced risk of stone formation in a large prospective cohort study involving more than 400,000 participants in the UK biobank, over a mean of 6.1 years of follow-up (23). Meta-analysis of observational studies has demonstrated a dose-response effect, with every 0.5L per day of fluid intake progressively reducing kidney stone formation (24). The benefit of higher fluid intake and the evident dose-response relationship has led to the recommended 2.5L per day urine output, while ensuring all people with kidney stones receive benefit even when they fail to achieve the higher 2.5L urine output target.

The focus is on the total fluid intake rather than the fluid type, with water generally the most affordable and available option. Water itself will vary in its mineral composition and pH; however, there is no compelling evidence to make a recommendation in this regard. Some beverages, particularly fruit juices, have been studied in more detail, due to their naturally high citrate content (25, 26). Citrate acts as an inhibitor of stone formation by complexing with calcium in the renal tubule, preventing nucleation of calcium phosphate and calcium oxalate, partly through interactions with tamm-horsfall protein. Although fruit juice in general is thought to be a good source of citrate, the citraturic effect is dependent on the alkali content of the juice, possibly explaining the differing propensity to reduce the risk of kidney stones. While orange juice, lemonade, and lemon juice have comparable citrate contents, the alkali content of orange juice explains its citraturic effect. The citrate in lemon juice is predominantly in the form of citrate acid which produces an acid load by generating a hydrogen ion, which neutralises the bicarbonate released when citrate is absorbed, hence reducing its citraturic potential.

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Benefits and harms

CARI Guidelines identified relevant systematic reviews and randomised controlled trials (RCTs) that examined increased fluid intake compared to regular fluid intake.

Increased fluid intake compared to regular fluid intake

A Cochrane review (17) assessed the benefits and harms of increased fluid intake to prevent kidney stones (27). Only one RCT (*n* = 199) (18) was included and found that kidney stone recurrence was lower in the increased fluid intake (2.0L/day urine output) group compared to regular fluid intake: 12% compared to 27% (RR = 0.45, 95% CI: 0.24, 0.84). The average interval for recurrence was 3.23 ± 1.1 years in the increased fluid intake group, compared to 2.09 ± 1.37 years in the regular water intake group (MD = 1.14 years, 95% CI: 0.33, 1.95).

The inclusion of a second study in a systematic review (20) that examined an increased urine volume output of 2.5L per day demonstrated decreased kidney stones recurrence (RR = 0.4 95% CI: 0.2, 0.79) compared to regular urine output. No gender differences have been demonstrated, with the consistent benefit of high fluid intake evident in both men and women (28). A meta-analysis of observational studies found increased fluid intake (>2.0L/d) was also associated with decreased risk of kidney stones compared to regular intake (1.5L/d) (RR = 0.49 95% CI: 0.34, 0.71; I^2 = 92%), with a dose-response effect evident: every 0.5L increase in fluid intake was associated with reduced kidney stone formation (24). There has been little reporting of potential harms of increased fluid intake; however, across studies, the dropout rates in participants on high fluid intake compared to regular fluid intake were similar.

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Certainty of the evidence

Overall, the certainty of the evidence is moderate. The included systematic reviews all displayed serious methodological limitations. The included RCTs, and observational studies examined in the meta-analysis, exhibited serious risk of bias concerns. The certainty of the evidence grading was upgraded due to large effect estimates on stone recurrence and evidence of a dose-response relationship between fluid intake and kidney stone recurrence from the observational studies.

Preferences and values

The two CARI Guidelines consumer workshops conducted in Auckland and Whangārei, Aotearoa New Zealand identified a lack of understanding about fluid intake and targets. They emphasised the need for consistent advice regarding fluid intake and individual targets, identifying it as a key priority.

> *"The first time I had my laser surgery, no one ever mentioned to me [that] drinking water is so important… I wasn't told…"* (Female, 60-69 years old, Whangārei)

> *"It was a long time before I learned drinking more water was so important, but now I don't know how much I need to drink so maybe I am over shooting?"* (Male, 60-69 years old, Auckland)

Similarly, a qualitative study of 33 participants from Ireland with experiences of kidney stones found that fluid intake was considered an essential aspect of self-management for kidney stones. Participants positively described the ability to make dietary changes and increase their

fluid intake, as doing this provided them with a sense of control over potentially helping prevent future episodes (29).

Equity

In Australia and New Zealand, those in rural and remote locations and in warmer climates have the most limited access to water. These areas are often subject to threats of water scarcity. They are socioeconomically deprived and have a high proportion of Aboriginal and Torres Strait Islander Peoples in Australia and Māori in New Zealand (30, 31). In addition, some occupations have restricted access to fluids or bathroom breaks, impacting how much fluid a person can consume throughout the day. The CARI Kidney Stones Consumer Workshops reiterated the importance of fluid intake targets being achievable, considering occupations and lifestyle:

> *"You're in the truck, 16, 12 hours a day. Water and that doesn't last long. Having to go to the toilet somewhere, especially for truck drivers. That's one of the biggest problems in New Zealand, there's nowhere to stop. You can't just pull over on the side of the road because the road can cave away on you; or, if the truck goes to a certain angle and it's heavily loaded, it will actually flip over. So, where do you go? You sit and you hold it in, and you hold it in, and you hold it in…"* (Male, 60-69 years old, Whangārei)

> *"I need to know the nearest toilet wherever I go somewhere and sometimes there are places I can't go."* (Male, 40-49 years old, Auckland)

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No other domains (gender/sex, religion, education, and social capital) of the equity checklist (PROGRESS Plus) (32) would be impacted by our recommendation.

Resources and other considerations

The focus is on total fluid intake, rather than type of fluid, with water generally the most affordable and available option. The implementation of a urine output target of 2.5 litres should be achievable and individualised to all people with kidney stones, as highlighted in the practice points below.

Practice Points

- **High fluid intake dilutes the urine and is the most important factor to prevent kidney stones.**

- **An individualised approach is necessary to guide fluid intake. Factors such as extra-renal losses, exercise, environment and co-morbidities should be taken into consideration. People with kidney stones who are at risk of volume overload require careful tailoring of advice to prevent fluid imbalance and electrolyte disorders.**

- **All fluids contribute to meeting fluid requirements, with water being the most beneficial, while sugar-sweetened beverages such as soft drinks are associated with a higher stone risk and should be discouraged.**

- **Guidance on timing of fluid should encourage an even distribution throughout the day. Support using app-based technology and smart beverage bottles may be helpful.**

Rationale

Participants at the two CARI Kidney Stones Consumer Workshops conducted in Auckland and Whangārei, Aotearoa New Zealand, shared the usefulness of using app-based technology to help monitor fluid intake throughout the day.

> *"There's a water app I use. Just to remind me because it does come up on a reminder. So, it's okay, drink lots of water but don't guzzle a whole litre in one go, because your body can't tolerate that. So, it makes sure that I sip throughout the day."* (Female, 40-49 years old, Whangārei)

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Participants at the workshop often described the impact of increased fluid intake on their social engagement, with one participant sharing due to the inconvenience of constantly needing to use the bathroom, they withdrew from activities with friends and family.

> *"Wherever you go... the first thing... where's the toilet…? There's the social impacts, of "Where's the bathroom?" … I have to go to the bathroom every 20 minutes…"* (Male, 40-49 years old, Auckland)

Timing and guidance on fluid intake may help combat urinary frequency and urgency issues which decrease the health-related quality of life for people with kidney stones (33, 34).

- **People with cystine stones should aim for a daily urine output of greater than 3 litres.**

Sodium intake

b. We recommend a daily sodium intake of less than 100 mmol (2300 mg) in people with calcium-based stones. *(Strong recommendation, low certainty of the evidence)*

Rationale

Physiologically, a sodium intake greater than 2300 mg is associated with approximately a 40 mg increase in urine calcium excretion (35), increasing the risk of calcium-containing stone formation (36). The expanded extra-vascular volume and competition for reabsorption with

calcium in the renal tubule increases the propensity for sodium to induce hypercalciuria. Sodium may also reduce urinary citrate (37). A low sodium intake has been demonstrated to decrease 24hr urine calcium after 3 months in people with kidney stones from a single-centre RCT in Italy (38). Additionally, the combined effect of a low sodium/low animal protein and normal calcium intake was proposed as the mechanism for reducing urine calcium and stone recurrence in people with idiopathic hypercalciuria when compared to a low calcium intake. (39).

Benefits and harms

RCTs have demonstrated the benefit of low sodium intake in preventing kidney stone recurrence (38, 39). An RCT of 210 adults with idiopathic calcium stones and hypercalciuria (>300 mg Ca/d in men and >250 mg Ca/d in women) from a specialist outpatient clinic of the University Hospital of Parma, Italy, were randomly assigned to receive either water therapy alone (control) or a low-sodium diet with water therapy for three months (38). On average, participants on the low-sodium diet achieved a 70% reduction in urine sodium. Compared to water therapy alone, a low sodium diet decreased urine sodium (MD = –132.00 mmol/day, 95% CI: –146.70, –117.3). In addition, those on the low sodium diet had lower urine calcium (mg/d) (MD = –90.00, 95% CI: –120.53, –59.47), oxalate (mg/d) (MD = –4.00, 95% CI: –6.53, –1.47), chloride (mmol/d) (MD = –123.00, 95% CI: –141.45, –104.55) and phosphorous (mg/d) (MD = –92.00, 95% CI: –159.31, –24.69). There was no reporting of clinical events of stone recurrence.

However, another RCT found kidney stone recurrence was lower (*n* = 120, RR = 0.49, 95% CI: 0.24, 0.98) in men with recurrent calcium oxalate stones and hypercalciuria receiving the normal calcium (30 mmol/d), low sodium (50 mmol/d), and low animal protein (52 g/d) diet, compared to those receiving a low calcium (10 mmol/d) diet alone after four years of follow-up (39). Similarly, observational studies have not been able to delineate the individual effect of sodium intake in the prevention of kidney stones. The National Health and Nutrition Examination Survey (NHANES) datasets have found, after adjustment, that healthy eating, including moderation of sodium intake, is associated with a decrease in kidney stones among 30 368 American Adults (11). However, there has been little examination of potential harms of low sodium intake across the studies.

Certainty of the evidence

The certainty of the evidence was graded as low. The reasons for downgrading include imprecision for the clinical outcomes of recurrence and relapse, and methodological limitations of the included studies, as there were insufficient details to judge the blinding of study personnel and outcome assessors of the included RCTs.

Preferences and values

Participants in the CARI kidney stones consumer workshops identified the need for clear and consistent evidence-based information regarding nutrition information. Most participants shared that reducing their sodium intake was one of the first recommended nutrition strategies. Individuals could limit the sodium added in cooking and at the table. However, they did not receive consistent information on the sodium content of processed foods, how to identify it (through label reading), or a daily sodium intake limit.

> *"…you've got another barrage of sometimes the same information, sometimes different..."* (Female, 60-69 years old, Whangārei)
>
> *"You go to one doctor, and they tell you one thing and then you go to another, and they tell you something else"* (Female, 60-69 years old, Whangārei)
>
> *"We just want the correct/evidence-based information given to us in plain English"* (Female, 60-69 years old, Whangārei)

Despite healthy eating guidelines being available (40-42), the average daily sodium intake in Australia and New Zealand is above the recommended intake (43, 44). These guidelines recommend limiting sodium intake to support clear, consistent, and realistic shared decision-making for people with recurrent kidney stones and clinicians; importantly, the communication and delivery of this information must be considered.

Equity

The average daily sodium intake for Australia and New Zealand adults is 158 mmol sodium. A reduction by 1/3 is necessary to limit sodium intake to the recommended level of 100 mmol (45, 46). Even higher average daily sodium intakes may be seen in certain cultures where high-sodium condiments are used liberally in cooking, where certain types of food high in sodium are routinely consumed, and where cooking methods and eating patterns may vary. Tailoring diets to limit sodium intake across cultural groups must be considered. Those living in rural and remote areas may also face increased difficultly accessing whole foods to support a low sodium diet (47).

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Resources and other considerations

Limiting sodium intake to below the recommended level will require a transition away from reliance on processed food to whole, fresh food consumption. Consideration of higher costs and availability of whole and fresh food means that a tailored approach by dietitians is essential to make this practical and deliverable for all people with recurrent kidney stones. Verified evidence-based internet resources and apps may be helpful to support people with kidney stones in making this transition.

Practice Points

- **A reduced sodium intake and choosing foods low in sodium are key to a healthy eating pattern. Most of the sodium in food is found in processed foods, with only approximately 10-20% from discretionary salt.**

Rationale

Sodium consumption in Australia and New Zealand adults is higher than the recommended daily intake, with estimates ranging from 145 mmol/day (43) to 158 mmol/day (44). World Health Organisation (40), and Australian (41) and New Zealand (42) guidelines all recommend reduced sodium intake, with avoidance of high levels of processed food, particularly ultra-processed foods.

- **A low-sodium diet can be difficult to achieve due to over-reliance on processed foods which are often cheaper, more available, and require little preparation.**

- **The potential for thiazide diuretics to reduce urinary calcium is enhanced when combined with a reduction in dietary sodium.**

- **24-hour urine sodium is a good estimate of total sodium intake.**

Rationale

Dietary food records have been demonstrated to be an unreliable estimator of 24-hour urine sodium. Systematic reviews have demonstrated that 24-hr dietary recalls may be unreliable in determining 24-hr urinary sodium, with correlation ranging from 0.16 to 0.72 (48). However, other systematic reviews have found that 92.8% (95% CI: 90.7, 95.0) of dietary sodium is excreted in the urine when measured by 24-hour urine sodium (49). Additionally, 24-hour urine sodium has been demonstrated to be 607mg/d (95% CI: 366, 847mg/d) higher than indicated on 24-hour dietary recall (50). While 24-hour urine collection is practically difficult and affected by changes in working schedules, as well as seasonal and climate conditions, it is more accurate than spot or other short-term urine collection methods (51).

DRAFT

Calcium and oxalate intake

c. We recommend achieving the recommended dietary intake for calcium (1000 mg for adults <70 years of age) in people with calcium stones, especially in those with high urine oxalate.

(Strong recommendation, moderate certainty of the evidence)

Rationale

An inverse relationship between dietary calcium and the risk of kidney stones has been demonstrated across observational studies (52-54). An adequate calcium intake is required to bind oxalate in the gut and reduce oxalate bioavailability (55). In malabsorptive conditions, increased gut free fatty acids sequester dietary calcium and reduce its potential to bind with oxalate, leading to increased oxalate absorption, hyperoxaluria and a greater risk of calcium oxalate stone formation (56). RCT evidence demonstrates the benefit of normal calcium intake in reducing recurrent stone formation compared to low calcium diets (39). Observational data has demonstrated that higher calcium intake, compared to lower intake, is associated with a large reduction in incidence of kidney stones (53, 54). The recommended dietary intake for calcium of 1000 mg for people under 70 years of age (57) is specified as most people with kidney stones are under 70 years of age (8).

Benefits and harms

An RCT involving adult men with recurrent calcium oxalate stones and hypercalciuria, who received a diet containing normal calcium intake (30 mmol/d), reduced intake of animal protein (52 g/d) and reduced salt intake (50 mmol sodium chloride) experienced a reduction in recurrent kidney stones (*n* = 120, RR = 0.49, 95% CI: 0.24, 0.98) after five years, compared with a low-calcium diet (10 mmol/d) (39). The effect may be explained by increased urine oxalate in the low-calcium arm, compared to control (MD = 78.00 µmol/d, 95% CI: 26.48, 129.52) at five years follow-up. Urine calcium decreased by 170 mg/d (4.2 mmol per day) in both groups during follow-up. The RCT reported no differences in adherence between the men with recurrent stones and those without in both study arms. There was limited reporting of adverse events related to dietary change.

Calcium intake has been found to be inversely related to the risk of kidney stones in large epidemiological studies. The Health Professionals Follow-up study found that, in 45 619 adults aged 40 to 75 years, the highest quintile of calcium intake compared to the lowest quintile reduced kidney stones risk (adjusted RR = 0.56, 95% CI: 0.43, 0.73) (53). However, the United States National Health and Nutrition Examination Surveys confirmed the reverse association in lowest dietary calcium quintiles compared to highest quintiles (adjusted OR = 0.59, 95% CI: 0.41, 0.85) across models in 15 364 adults from 1976 to 1980, and 16 115 adults from 1988 to 1994 (54). Further, a U-shaped pattern, in which low calcium intake and high calcium intake increased the risk of kidney stone recurrence has been described in a case-control study (*n* = 469 people with kidney stones, *n* = 384 controls) (52).

Certainty of the evidence

The certainty of the evidence is moderate. The identified RCT demonstrated methodological limitations with no blinding undertaken and limited information to assess concerns about participant attrition. The certainty of the evidence was downgraded due to serious imprecision with only one study available.

Preferences and values

Participants at the CARI kidney stones consumer workshops identified the need for clear and consistent nutrition information, and management strategies that were not overly restrictive, achievable and consistent with lifestyle and cultural preferences. Participants unanimously shared their experiences of receiving conflicting nutrition advice from different clinicians or sources, as well as information that was jargon-laden and confusing. Lack of explanation when delivering nutrition advice contributed to this confusion.

> *"And then you've got another barrage of sometimes the same information, sometimes different… you go to one doctor, and they tell you one thing, you go to a specialist, and they tell you something else…"* (Female, 60-69 years old, Whangārei)

> *"Come straight out with it. But in plain English. No jumbled words."* (Male, 60-69 years old, Whangārei)

> *"I am confused because we need to eat foods high in calcium and yet we have calcium stones…"* (Male, 20-29 years old, Whangārei)

Equity

Certain ethnic populations have higher rates of lactose intolerance, particularly cultures without traditional dairy milk consumption, such as east Asian and Middle Eastern populations (58). The implementation of these recommendations through engagement with a dietitian with experience in the management of kidney stones will ensure that diets are tailored to the individual, and that people with kidney stones can enjoy a nutritious and whole food diet that is sustainable, which will decrease kidney stone recurrence.

Resources and other considerations

Achieving a normal calcium intake is not expected to result in increased costs for people with recurrent kidney stones.

d. We recommend against a low oxalate diet for the management of calcium oxalate stones.

(Strong recommendation, very low certainty of the evidence)

Rationale

DRAFT

Oxalate is found in a wide range of foods, especially plant based; however, endogenous oxalate from metabolism of glycine, glycolate, hydroxyproline and vitamin C also contributes to urinary oxalate excretion. There is limited evidence that a low oxalate diet reduces the risk of calcium oxalate stones. Alternatively, reducing bioavailability of dietary oxalate by optimising calcium intake offers an approach that is both effective and safe (56, 59). The low oxalate diet limits many foods potentially offering reduced lithogenic risk by limiting citraturic plant-based foods, reducing magnesium content (60), and reducing overall diet quality with negative effects on the gut microbiome (56), potentially increasing the risk of kidney stones (11). Contradictory lists of oxalate-containing foods have the potential to confuse people with kidney stones and shift the focus away from more important, evidence-based dietary advice for reduction of stone recurrence (61).

Benefits and harms

Large prospective cohort studies, Health Professionals Follow-up Study (*n* = 45 985 men), Nurses' Health Study I (*n* = 97 872 women) and Nurses' Health Study II (*n* = 101 824 women) have demonstrated a small association between the highest levels of dietary oxalate and incidence of kidney stones (59). The magnitude of effect was modest, even in the population low in calcium. The five-year RCT comparing the normal calcium (30 mmol/d), animal protein (52 g/d) and sodium (50 mmol/d) diet to the low calcium (10 mmol/d) diet also recommended avoidance of high oxalate food, and found a reduction in kidney stone recurrence (39). However, the study did not specifically examine dietary oxalate, and the effect cannot be determined in isolation. There has been little to no examination of harms of low oxalate intake across these studies.

Certainty of the evidence

The certainty of the evidence is low, as the data is mostly observational and there are concerns related to indirectness of results, with RCTs that have examined multiple elements in the intervention.

Preferences and values

Some participants at the CARI kidney stones consumer workshops had received information on low and high oxalate-containing foods. The information was not accurate or reflective of the current evidence and highlighted the prevalence of outdated guidance on dietary oxalate intake for people with recurrent kidney stones.

> *"It was really difficult to get good information about a low oxalate [diet], and really difficult to keep to because I was already restricting other foods*." (Male, 40-49 years old, Auckland)

Avoidance of prescribing low oxalate diets will ensure people with kidney stones and their caregivers are not provided conflicting information. Focusing recommendations to be less restrictive and to support whole food consumption will improve diet quality and satisfaction for people with kidney stones.

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Equity

The Working Group identified no equity-related concerns regarding the implementation of this recommendation.

Resources and other considerations

There are no known concerns regarding the costs and resources required to implement the avoidance of low oxalate diets. The implementation of this updated recommendation to avoid the generalised prescription of a low oxalate diet will limit the need for people with kidney stones to follow restrictive diets, which should help to make dietary self-management more achievable.

Practice Points

- **For adults ≥70 years of age the recommended dietary intake for calcium is 1300 mg.**

Rationale

The recommended dietary intake for calcium is 1300 mg for people 70 years of age and older (57).

- **A low calcium diet leads to increased absorption and urinary excretion of oxalate, resulting in oxaluria, has no effect on decreasing kidney stone recurrence, and may decrease bone density.**

- **Oxalate is present in a wide variety of foods, including many healthy foods, and it is difficult to reduce significantly while maintaining a balanced diet.**

- **Where there is high urinary oxalate, calcium fortification at mealtimes is recommended to reduce oxalate bioavailability. Include high calcium foods such as milk, yogurt, cheese or calcium fortified non-diary alternatives.**

- **Calcium supplements may be considered to achieve recommended daily calcium intake and should be taken at mealtimes to achieve beneficial binding of oxalate.**

- **Enteric hyperoxaluria due to malabsorption requires a tailored approach. Calcium supplementation, limiting high oxalate if consumed excessively and/or frequently without a calcium source, and/or a low-fat diet may be required.**

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- **Magnesium can also bind oxalate and reduce oxalate absorption. Magnesium supplementation may be beneficial if urine magnesium is low. Diarrhoea may limit tolerance and dosing.**

- **Limit vitamin C intake from supplements, i.e., doses exceeding 500mg per day.**

- **Vitamin D within recommended daily intake is not associated with increased kidney stones.**

Fruit and vegetables, and animal protein

e. We recommend a diet rich in fruits and vegetables, limiting intake of non-dairy animal protein.

(Strong recommendation, low certainty of the evidence)

Rationale

Diets in Australia and New Zealand have a high dietary acid load, which refers to the capacity of foods to promote production of acid in the body, which must be excreted via the kidneys in the urine (62). Non-dairy animal protein intake increases the renal acid load, i.e., reduces urine pH. A high renal acid-load increases urine calcium by decreasing tubular calcium reabsorption, increasing bone reabsorption and increasing calcium absorption in the gut (63). Additionally, higher acid load from high non-dairy animal protein intake increases citrate reabsorption,

leading to a decreased urine citrate (64). Both the increased urine calcium and decreased urine citrate heighten the risk of kidney stones (65).

Increased fruit and vegetable consumption has an alkalinising effect and is known to balance pH and improve urinary citrate (66). While there is no definitive clinical data to support non-dairy animal protein restriction for stone prevention, animal protein intake should follow levels recommended in healthy eating guidelines (1, 2, 57), as high intake is discouraged. Dietary acid load may be reduced by lower consumption (e.g., smaller portions, lower frequency of consumption) of meats, cheeses, and grains, higher consumption of fruits and vegetables, or a combination of both to meet nutrient requirement (67). Dietary acid load should be considered when assessing the nutritional intake of people with kidney stones, especially those potentially formed from overly acidic urine. Intake of non-dairy animal protein and grains should be considered, as these food groups contribute the most to dietary acid load (67). Promoting intake of fruits and vegetables can help mitigate dietary acid load and, therefore, reduce urine acidity (67, 68).

Benefits and harms

An RCT conducted in a single outpatient nephrology unit in France included 96 adults with idiopathic calcium stones found that around 39% of those assigned to low animal protein diet (<10% of total energy) compared to normal diets decreased urea by more 50 mmol/day which corresponded with a decrease in urine calcium by about 1.8 mmol/day. There was no examination of the effect on kidney stone recurrence in the study (69). Observational studies have demonstrated that animal protein is negatively associated with renal acid load, i.e., reduces urine pH, while fruit and vegetables contribute a strong alkali load, i.e., increase urine pH (67). The Nurses' Health Study found that there was no increased risk of kidney stone formation in the highest quintile compared to lowest quintile for animal protein consumption (Nurses' Health Study I: RR/HR = 1.15, 95% CI: 0.97, 1.36; Nurses' Health Study II: HR = 1.20, 95% CI: 0.99, 1.46) (70). There has been little examination of potential harms in these studies, but consumption of fruit and vegetables and non-animal protein as part of a balanced diet should be safe and good for overall health.

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Certainty of the evidence

The certainty of the evidence is low. The included RCT exhibited study limitations and generated serious concerns about imprecision, since there was only one study. Observational studies have not examined all relevant outcomes required for an assessment of benefits and harms of treatments.

Preferences and values

Participants at the CARI kidney stones consumer workshops highlighted the need for consistent information regarding diet. A focus on evidence-based diets that could be realistically incorporated into everyday life were prioritised by people with lived experiences of kidney stones.

Equity

Rural and remote patients may face difficulties accessing whole foods, with higher costs for fruit and vegetables in these areas in Australia and Aotearoa New Zealand (47, 71). Marginalised communities will often achieve lower rates of recommended fruit and vegetable

intake, hence requiring tailored advice from dietitians to support a diet that improves acid load and may help to prevent kidney stone recurrence.

As evidenced below, a participant in the Whangarei CARI kidney stones consumer workshop, who lives in a rural area, emphatically highlighted the financial realities of making dietary changes, and the frustration arising from inconsistent and changing nutrition-related advice.

> *"You give me all of this to help me with my kidney stones, but it's so **** expensive, I can't afford it. [others affirming] Being on the benefit, I can basically just afford my rent. I haven't got money for food. I haven't got money to pay my other bills. Now you expect me to go into the shop and pay 10 bucks for a small box of something that they're supposed to be good for me? And now all of a sudden, these other doctors come out and say, "Yeah, but that's not good for you…" Who do you listen to? What do you eat?"* (Male, 60-69 years old, Whangārei)

It is important to note that the consumption of fruits and vegetables varies across ethnic groups and consideration of food security is fundamental to providing appropriate, culturally considered recommendations that will support long-term adherence to nutrition therapy advice. The incorporation of traditional foods for Aboriginal and Torres Strait Islander Peoples in Australia and Māori in Aotearoa New Zealand is a strength-based approach that moves the focus away from restriction. The CARI First Nations Guidelines provide some guidance for considering traditional foods and food security (72, 73).

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Resources and other considerations

Incorporation of seasonal and local food is vital to ensuring incorporation of fresh fruit and vegetables into daily diets and ensuring costs are sustainable for people with recurrent kidney stones.

Practice Points

- **Healthy eating guidelines suggest at least two serves of fruit and at least five serves of vegetables daily.**

Rationale

Increased fruit and vegetable consumption is known to balance pH and improve urine citrate (66). Fruits and vegetables balance the renal acid load from animal protein consumption, which can otherwise lead to increased kidney stone formation (65).

- **High intake of non-dairy animal protein is associated with an increased risk of stones. We recommend a moderate protein intake within the Australia and New Zealand Healthy Eating Guidelines.**

- **Dairy protein intake is associated with a reduced risk of stone formation and vegetable protein sources are not known to influence stones risk.**

- **Uncertainty exists around stone risks associated with protein supplements such as whey isolates and with creatine supplementation, thus their safety cannot be assured in people with kidney stones.**

Rationale

The use of protein supplements such as whey isolates in competitive sports and regular gym attenders is widespread, as is the use of creatine. These supplements have not been adequately studied in people with kidney stones, their risk profile is unknown and, therefore, their safety for people with kidney stones cannot be assured. Alternative dietary strategies, which are known to be less lithogenic, should be explored as alternatives (74).

- **Potassium citrate supplementation may be required, in addition to enhanced intake of fruit and vegetables, to achieve alkalinisation of the urine and increase urinary citrate levels.**

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Suggestions for future research

Nutrition in kidney stone prevention should be further explored to understand the following:

- Investigate the impact of different dietary patterns on kidney stone formation rates and recurrence (e.g., Mediterranean diet, DASH diet)
- Assess the efficacy and safety of dietary supplements, citrate supplementation, and probiotics as adjunctive treatments for preventing kidney stone formation.
- Bariatric surgery: Assess the impact of Roux-en-Y gastric bypass surgery on oxalate excretion and the formation of kidney stones.
- Microbiome and kidney stones: Examine the diverse microbes found in the microbiome, their impact on oxalate metabolism, and potential impact on kidney stones.
- Counselling/behaviour: examine behavioural factors that influence long-term adherence to nutrition recommendations for kidney stone prevention and identify effective strategies for promoting sustained behaviour change.
- Integration of technology: Explore the use of technology-based interventions (e.g., mobile apps) to support nutrition monitoring, behaviour modification, and self-management in individuals with recurrent kidney stones.
- Assess the effectiveness and economic impact of nutrition interventions for kidney stone prevention, considering healthcare costs, productivity losses, and quality of life outcomes in Australia and New Zealand.

CARI GUIDELINES
CARING FOR AUSTRALIANS & NEW ZEALANDERS WITH KIDNEY IMPAIRMENT

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Conflict of interest

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