



DIETARY FACTORS IN KIDNEY STONE DISEASE: A SPECIAL FOCUS ON THE VEGETARIAN DIET

Czynniki dietetyczne w kamicy nerkowej:
ze szczególnym uwzględnieniem diety wegetariańskiej



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Abstract

Kidney stones are a widespread medical issue that affects around 11% of the global population. They can be very painful and tend to recur. Their formation is complex and influenced by several factors, such as being overweight, not drinking enough fluids, eating poorly, and having long-term health conditions. This shows how important it is to implement effective prevention methods, with diet playing a key role. The purpose of this review is to look at the issue of kidney stones and to find out whether a vegetarian diet could be an effective way to prevent or treat them. Available evidence suggests that a vegetarian diet can be helpful in preventing and managing kidney stones. Potential benefits include 1) lower risk of calcium-oxalate stones: fruits and vegetables in a vegetarian diet contain high levels of citrates, which helps keep calcium in the urine and stop stones from forming. 2) prevention of uric-acid stones: a vegetarian diet is lower in purines, resulting in reduced urinary uric acid. 3) urine pH balance: the diet is rich in potassium and magnesium, helping to make the urine more alkaline, which supports the dissolution of uric-acid and cystine stones. 4) Oxalate balance: although some plant foods have high oxalate levels, a balanced vegetarian diet with adequate calcium can reduce intestinal oxalate absorption. A well-planned vegetarian diet can therefore be a useful tool for preventing and managing kidney stones. Its benefits stem from the ability to make urine more alkaline, lower uric acid levels, and increase citrate levels that protect against stones. However, it is important to ensure adequate calcium intake to counterbalance oxalate intake. More research is needed to fully understand the long-term benefits and possible risks of vegetarian dietary patterns for kidney health.

Streszczenie

Kamica nerkowa jest powszechnym problemem medycznym, który dotyka około 11% populacji na całym świecie. Może powodować silny ból i ma tendencję do nawrotów. Proces jej powstawania jest złożony i zależy od wielu czynników, takich jak nadwaga, niewystarczające nawodnienie, nieprawidłowa dieta oraz choroby przewlekłe. To podkreśla, jak ważna jest skuteczna profilaktyka, w której kluczową rolę odgrywa dieta. Celem niniejszego przeglądu jest omówienie czynników dietetycznych związanych z kamicią nerkową oraz ocena potencjalnej roli diety wegetariańskiej w jej profilaktyce i leczeniu. Dostępne dane sugerują, że dieta wegetariańska może wspierać profilaktykę i leczenie kamicy nerkowej. Do potencjalnych korzyści należą mniejsze ryzyko powstawania kamieni szczawianowo-wapniowych, związane z większą podażą cytrynianów pochodzących z owoców i warzyw, oraz mniejsze wydalenie kwasu moczowego z moczem w związku z niższym spożyciem puryn. Dieta bogata w potas i magnez może również sprzyjać alkalizacji moczu, co jest korzystne w profilaktyce kamicy moczowej. Dobrze zaplanowana dieta wegetariańska może być skutecznym narzędziem w profilaktyce i leczeniu kamicy nerkowej. Jej korzystne działanie wynika z możliwości alkalizacji moczu, obniżenia poziomu kwasu moczowego oraz zwiększenia stężenia cytrynianów chroniących przed kamieniami. Należy jednak pamiętać o dostarczaniu odpowiedniej ilości wapnia, aby zrównoważyć spożycie szczawianów. Konieczne są dalsze badania, aby w pełni ocenić długoterminowe korzyści i potencjalne zagrożenia związane z dietą wegetariańską dla zdrowia nerek.

Keywords: urolithiasis; kidney stones; vegetarian diet; urinary tract stones; risk factors for kidney stones

Słowa kluczowe: kamica nerkowa; kamienie w drogach moczowych; dieta wegetariańska; urolitaza; czynniki ryzyka kamicy nerkowej

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Introduction

Kidney stones are a common condition affecting individuals around the world today [1]. People have been dealing with this issue for a long time, with early descriptions dating back to ancient Mesopotamia, between 3200 and 1200 BCE [2]. The way kidney stones form is complex and influenced by many factors [3]. One of these factors is diet and how it affects the urinary system [4]. This paper discusses how kidney stones form and how a vegetarian diet may influence this process.

Research objective

The aim of this review is to examine how a vegetarian diet influences the development of kidney stones, focusing on latest research and current scientific knowledge.

Research problems

Although kidney stones are very common and often recur, there is no single explanation for how all types of stones form. This highlights the need for better prevention strategies, and looking closely at how a vegetarian diet might help is important.

Research hypotheses

A vegetarian diet may help prevent kidney stones by altering the composition of urine and its pH, which can reduce the likelihood of stones forming and recurring.

Research materials and methods

The review is based on an analysis of research papers and articles found in databases such as Google Scholar and PubMed.

We used keywords such as “vegetarian diet,” “urinary tract stones,” “kidney stones,” “urolithiasis,” and “risk factors for kidney stones” to identify relevant studies. All team members were involved in searching for and analysing the literature, as well as interpreting the findings.

Artificial intelligence (AI)

Artificial intelligence was used only to improve the language quality of the paper. It helped make the writing clearer and more consistent with scientific standards by correcting grammar and style. It is important to note that AI was just a support tool under human supervision. It did not replace human judgment in analysing the data or drawing conclusions. All facts and final interpretations were made by the human authors.

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Research results

Types of kidney stones

Kidney stones are made of both organic and crystalline materials [5]. The most common type is calcium oxalate. There are several different kinds of kidney stones. Up to 80% of all urinary stones are calcium-based, including calcium phosphate and calcium oxalate. Struvite and magnesium phosphate stones account for 10 to 15% of all cases. Uric acid stones make up about 3 to 10%, and cystine stones less than 2%. Some rare types of kidney stones can be caused by certain medications, such as guaifenesin, triamterene, atazanavir, and sulphonamide drugs [6].

Epidemiology of kidney stones

Kidney stones are a widespread problem affecting people worldwide. A study in the United States using data from the National Health and Nutrition Examination Survey (2015–2018) found that up to 11% of people had kidney stones [7]. The condition becomes more common with age. For example, among men aged 20 to 39, the rate was 5.1%, but it increased to 19.7% in men aged 80 and older. Among women, the rate was 5.8% for those aged 20 to 39 and 10.6% for those aged 80 and older [8]. In Asia, the incidence is estimated between 1 and 5%, in Europe between 5 and 9%, and in North America between 7 and 13% [9]. Because kidney stones often recur, they are a significant medical challenge. More than half of patients are expected to experience a recurrence within five years [10], and in some cases, the recurrence rate can be as high as 82.4% [11]. As the population ages, kidney stones are becoming more common, increasing the burden on health-care systems worldwide. Therefore, effective prevention and treatment of this condition are very important.

Risk factors

The development of kidney stone disease is influenced by many factors, both modifiable and non-modifiable. Diet plays a direct role in the formation of kidney stones [12]. Other risk factors include smoking, alcohol use, diabetes, obesity, and family history [13, 14]. Following an unhealthy diet, such as drinking sugary drinks, consuming large amounts of oxalate, and not drinking enough water, increases the risk [15]. Preventing and managing modifiable factors like diet, smoking, alcohol use, and weight is essential for treating kidney stones and preventing them from recurring.

Process of kidney stone formation

Because kidney stones occur in several different types, the mechanisms behind their formation also vary. There-

fore, there is no single pathway by which all kidney stones develop. Research shows that at least three main mechanisms are involved.

The first mechanism involves stones growing on interstitial apatite plaque [16] located in the papillary region of the kidney. This plaque is known as Randall's plaque, and it was discovered as early as 1937 [17]. The pathway involving Randall's plaque is linked to the formation of calcium oxalate stones. These stones form when crystals build up and persist in the urine even as it flows. This happens when crystals become large enough to adhere to the lining of the urinary tract or become trapped in the renal tubules before being passed out. It is believed that this retention and stone formation occur at the site of Randall's plaque. The plaque originates in the basement membrane of the loop of Henle and spreads into the interstitial medulla. As the plaque grows, it weakens the transitional epithelium, making it more vulnerable to the effects of urine and its chemical components such as osteopontin and Tamm-Horsfall protein. These urine substances interact with the plaque to form new layers of matrix and crystals. Eventually, a true calcium oxalate stone forms as crystals move into the urine space. This is the most common pathway by which calcium oxalate stones develop on Randall's plaque. Factors such as urine volume, pH, and calcium content are all connected to the presence of Randall's plaque [18].

The second mechanism involves crystal deposits in the renal tubules. Much about this process is still unknown. Urine pH and composition – especially calcium and phosphate concentrations – play a major role in how this process unfolds.

The third mechanism is called free solution crystallisation. This is best seen in the formation of cystine stones. It occurs when there is too much cystine in the urine, which can happen in a condition called cystinuria. When the concentration of cystine exceeds a certain point, it starts to form crystals that aggregate into kidney stones. Interestingly, these stones float freely and are not attached to the walls of the renal pelvis [16].

It is also important to consider how different urine components can either promote or inhibit stone formation. Uric acid and very acidic urine pH help crystals form, including uric acid crystals and calcium oxalate crystals. These crystals can act as templates, helping other types of crystals form. In contrast, substances such as citrate, pyrophosphate, and magnesium contribute to inhibiting the formation of stones [19]. Although the full details of how kidney stones form are not yet fully understood, it is likely that the balance and interactions between all these factors determine how stones develop in the urinary system.

Vegetarian diet and kidney stones

There are many different types of vegetarian diets described in the literature, but four are the most common: strict vegetarian, which avoids all animal products; pescatarian, which excludes meat but includes fish and seafood; ovo-lacto-vegetarian, which excludes meat but al-

lows eggs and dairy; and flexitarian, which limits or rarely includes red meat [20]. The main idea of vegetarianism is avoiding meat. The International Vegetarian Union defines it as a plant-based diet that may also include dairy, eggs, or honey [21]. Recent studies show that a vegetarian diet has many benefits, not just for the kidneys. It can reduce the risk of death from diabetes, chronic kidney disease, heart disease, and stroke [22]. A vegetarian diet also helps lower cholesterol, body weight, and blood pressure, and may help prevent certain chronic diseases, including cancer [23]. It has also been suggested as a supportive approach for kidney stone prevention because of its multiple benefits. A diet that increases citrate while reducing animal protein, oxalates, and sodium has been helpful for patients with calcium oxalate stones. Because obesity and metabolic syndrome can make urine more acidic, increasing the likelihood of uric acid stone formation, vegetarian diets help reduce weight and make the urine more alkaline, which prevents stones from forming. Eating less animal protein also helps lower uric acid content by reducing purine intake. In the case of cystine stones, lower animal protein intake is linked to reduced cystine and its precursor, methionine. Vegetables contain high amount of organic anions, such as citrate and malate, which raise urine pH and lower the risk of cystine stones because cystine is more soluble in alkaline urine [4]. A study on cystinuria showed that ten men who followed an ovo-lacto-vegetarian diet had lower levels of cystine and cysteine in their urine compared with those on other diets. Since fruits and vegetables make urine more alkaline, this diet appears effective against cystine stones [24]. However, a vegetarian diet has not been shown to be very effective against struvite stones, as these are usually caused by bacterial infections. For individuals with oxalate stones, a vegetarian diet may lead to higher oxalate intake, which could be problematic. Research by Thomas et al. found that people on a vegetarian diet had higher oxalate absorption and excretion than those on a mixed diet, although these concentrations were similar when oxalate intake was increased [25]. Adding more calcium to the diet helps prevent oxalate absorption and reduces the amount entering the urine, where stones can form. This is because calcium binds to oxalates in the intestines, making them insoluble and preventing them from passing into urine [26]. Individuals who are overweight are at higher risk of kidney stones. A vegetarian diet can help with weight loss by reducing high-calorie foods like meat, so a balanced vegetarian diet rich in fruits and vegetables and low in animal fats and proteins may lower the risk of kidney stones [27]. A study in India found that 81.8% of people with kidney stones did not follow a vegetarian diet [28]. A 2021 meta-analysis showed that higher intake of non-dairy animal protein and meat was linked to a higher risk of kidney stones, while higher dairy protein intake was associated with lower risk [29]. Another study found that factors such as consuming too much red meat, high BMI, and low water intake were common causes of kidney stones [30]. A Chinese study found that healthy vegetarians had better kidney function than meat-eaters, and the higher fibre content of vegetarian diets was also protective for kidney health [31]. Therefore, avoiding animal products may help reduce the risk of kidney stones. In the EPIC study, which included 51,336 participants, the risk of developing kidney stones was compared across dietary groups. Those who

ate moderate, low, or no meat had lower risks compared to those who consumed large amounts of meat. Vegetarians had the lowest risk [32]. Another study from the EPIC-Oxford group, which included 65,000 people in the United Kingdom, found that vegetarians were less likely to develop kidney stones, diabetes, cataracts, and heart disease compared with others. A vegetarian diet tends to be lower in fat, which is why it is often linked to weight loss. However, people who follow plant-based diets may have a higher risk of stroke and bone fractures compared with those who eat meat. This is because it can be harder to obtain enough of certain nutrients such as calcium, vitamin B12, and vitamin D from plant foods alone. To avoid these issues, it is important to add supplements to the diet [33]. Vegetarian diets also contain high amounts of magnesium, citrate, and potassium, which help prevent the formation of kidney stones. These nutrients reduce the levels of calcium oxalate and calcium phosphate in the urine. However, because of the risk of kidney stones, it is important to maintain a good balance between calcium, oxalates, and phytates in the diet. If there is not enough calcium in the gut to bind with oxalates from fruits and vegetables, problems may occur. Phytates can also bind calcium, preventing it from reacting with oxalates, which may lower the calcium content [34].

Discussion

Based on the findings of this review, a vegetarian diet can help prevent and manage kidney stones to some extent. The data suggest that reducing animal protein consumption and increasing plant-based meals rich in minerals such as citrate, potassium, and magnesium can improve urine composition, which in turn lowers the risk of stone formation. However, even though a vegetarian diet has several benefits, there are challenges that should be considered. One concern is the potential for higher oxalate intake from large amounts of vegetables, which may contribute to the formation of calcium oxalate stones if dietary calcium is insufficient. Therefore, vegetarian diets should be carefully balanced, especially with regard to calcium and oxalate content.

Also, the protective effects of vegetarian diets may not be the same for all types of stones. While there are clear benefits for calcium oxalate, uric acid, and cystine stones, struvite stones, which are caused by bacterial infections, may not respond well to dietary changes alone. Additionally, factors such as body weight, metabolic health, and hydration continue to play a significant role, regardless of eating patterns. Most current studies are observational or retrospective, and often include mixed factors that make it difficult to prove a direct cause-and-effect relationship.

In the future, more detailed studies, such as randomised trials, would be helpful to better understand how vegetarian diets affect the risk of kidney stones. When giving dietary advice, it is also important to consider individual differences in metabolism, nutrient absorption, and genetic factors.

Overall, the available evidence suggests that a well-planned vegetarian diet, along with good hydration and

attention to mineral balance, can be a helpful strategy for reducing the occurrence and recurrence of kidney stones. However, more high-quality research and personalised dietary recommendations are needed to improve prevention efforts for different groups of people.

Conclusion

A vegetarian diet appears to be a useful approach for preventing and managing kidney stones. However, it should be tailored to each patient to ensure effectiveness and avoid negative effects. It is important to maintain adequate calcium intake to counteract harmful oxalates. Above all, drinking plenty of fluids remains the most important factor in preventing stone formation. More research is still needed to better understand this condition.

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