ZINKOW-KRZEMYK, Karolina, KOTUŁA, Jacek, KAPLER, Marta, MĄSIOR, Magdalena Natalia and ŚWIERCZEK, Izabella. The role of vegetarian diet in Nephrolithiasis. Quality in Sport. 2024;32:55215. eISSN 2450-3118.
https://dx.doi.org/10.12775/QS.2024.32.55215
https://apcz.umk.pl/QS/article/view/55215

The journal has been 20 points in the Ministry of Higher Education and Science of Poland parametric evaluation. Annex to the announcement of the Minister of Higher Education and Science of 05.01.2024. No. 32553.
Has a Journal's Unique Identifier: 201398. Scientific disciplines assig589 ned: Economics and finance (Field of social sciences); Management and Quality Sciences (Field of social sciences).
Punkty Ministerialne z 2019 - aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 r. Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398.
Przypisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych).

The authors declare that there is no conflict of interests regarding the publication of this paper.
Received: 13.09.2024. Revised: 12.11.2024. Accepted: 13.11.2024. Published: 14.11.2024.

The role of vegetarian diet in Nephrolithiasis

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Abstract

Nephrolithiasis, commonly known as kidney stone disease, is a prevalent condition with significant morbidity worldwide. Notably, this medical condition is strongly influenced by nutritional habits. Dietary choices play a critical role in both the formation and prevention of kidney stones, highlighting the importance of proper nutrition in managing this disease. This review explores the impact of a vegetarian diet on nephrolithiasis. Evidence suggest that plant-based diets, which excludes animal protein, may contribute to a reduced risk of kidney stone formation.

Vegetarian diet could be also considered as higher in fruits and vegetables, so in conclusion, people on plant-based diet have a water-rich food intake. Not only the fluid intake, but also the balance of calcium and oxalates is very important in managing risk of forming kidney stones. This diet typically result in lower acid load, higher urinary pH and increased urinary citrate levels. Everything mentioned is a key preventive strategy against kidney calculi.

Nephrolithiasis has undenyable colligation with diet. Patients dietary choices and their lifestyle could strongly influence the course of this disease. Overall, well-planned vegetarian diet may offer protective benefits against nephrolithiasis. It should be individualized and preferably prepared by a professional dietitian. In this case, it is important to remember that our diet plays role similarly in genesis as in recurrence of kidney stone disease. Changing eating habits aims to reduce lithogenic risk factors.

Keywords: Kidney stones, Nephrolithiasis, Vegetarian Diet, Plant-based diet, Kidney Calculi

Introduction

Nephrolithiasis is a widespread disease which has undenyable colligation with diet. Patients dietary choices and their lifestyle could strongly influence the course of this disease. This article aims to assess how minor adjustments, such as reducing meat consumption or increasing fluid intake, could lower the risk of developing kidney stones.

Pathogenesis of Nephrolithiasis - Supersaturation, Crystallization, Nucleation, Crystal Growth and Aggregation

Nephrolithiasis affects a significant portion of the population worldwide, with varying prevalence based on geographical, dietary, and genetic factors. The development of kidney stones is a complex process that involves multiple biochemical and physiological pathways. Understanding these pathways is crucial for developing effective preventive and therapeutic strategies [1].

The primary step in kidney stone formation is the supersaturation of urine with respect to stone-forming salts such as calcium oxalate, calcium phosphate, and uric acid [2]. Supersaturation leads to the nucleation of crystals, which can subsequently grow and aggregate. Factors influencing supersaturation include urine volume, pH, and the concentration of promoters and inhibitors of crystallization [3][4].

Nucleation is the process by which free ions in the supersaturated urine come together to form a solid nucleus. There are two types of nucleation:

1. Homogeneous nucleation: Occurs in pure solutions without any foreign particles [5].
2. Heterogeneous nucleation: Occurs on pre-existing surfaces or particles, such as renal epithelial cells or urinary casts [6].

Once nucleation occurs, crystals can grow by the addition of further ions from the supersaturated urine. Crystal growth is dependent on urine pH, the presence of inhibitors like citrate and magnesium, and promoters like calcium and oxalate [7]. Aggregation refers to the clumping of smaller crystals to form larger particles, which is critical for the development of clinically significant stones [8].

For a stone to form, crystals must be retained within the renal tubules or interstitium rather than being washed away by urine flow. Factors contributing to crystal retention include abnormalities in renal anatomy, reduced urine flow, and the presence of Randall's plaques—calcium phosphate deposits in the renal papillae that serve as a nidus for stone formation [9][10].

Genetic and Environmental Factors

Genetic predisposition plays a significant role in nephrolithiasis, with several genetic mutations linked to hypercalciuria, hyperoxaluria, and other metabolic abnormalities [11][12]. Environmental factors such as diet, hydration status, and climate also significantly impact stone formation. High dietary intake of oxalate, sodium, and animal protein, along with low fluid intake, can increase the risk of kidney stones [13].

Pathophysiological Mechanisms

1. **Hypercalciuria**: Elevated levels of calcium in the urine, often due to increased intestinal absorption, renal leak, or bone resorption, are a common risk factor for calcium oxalate and calcium phosphate stones [14].
2. **Hyperoxaluria**: High urinary oxalate levels can result from dietary sources, increased endogenous production, or reduced degradation by intestinal bacteria. Oxalate readily binds with calcium to form calcium oxalate crystals [15].
3. **Hypocitraturia**: Citrate is a natural inhibitor of stone formation. Low urinary citrate levels can result from metabolic acidosis, renal tubular acidosis, or dietary factors [16].
4. **Hyperuricosuria**: Elevated uric acid in the urine can promote the formation of uric acid stones directly or act as a nidus for calcium oxalate stone formation [17].

Aim of the Study

The aim of this study is to evaluate the role of vegetarian diet in kidney stones formation and to provide a comprehensive overview of the current evidence on the role of this kind of diet in nephrolithiasis, focusing on both the protective benefits and potential risks associated with these dietary patterns. Explaining the complex interactions between dietary components and kidney stone formation can significantly contribute to develop dietary strategies for the prevention and management of nephrolithiasis. This study based on research seeks to present the relationship and inherent impact of alimentary habits on the formation of kidney stones.

Methods

This review synthesizes current evidence on the role of vegetarian diets in nephrolithiasis. A comprehensive literature search with a critical review of studies was conducted to assess the impact of a vegetarian diet on the formation, prevention and treatment of kidney stones. A systematic literature search was performed using databases including PubMed, Scopus, and Web of Science for articles. Studies were included if they met the following keywords: “kidney stones”, “nephrolithiasis”, “vegetarian diet”, “plant-based diet”, “kidney calculi”. Authors independently screened titles and abstracts for relevance. Full-text articles were then assessed for eligibility. Extracted data included study design, sample size, participant demographics, dietary assessment methods, outcomes measured, and key findings related to vegetarian diets and nephrolithiasis. Studies were rated based on selection, comparability, and outcome assessment for observational studies, and on randomization, allocation concealment, blinding, and outcome reporting for randomized controlled trials. Discrepancies in quality assessments were resolved through discussion and consensus.

Nephrolithiasis

Nephrolithiasis, as it was mentioned, is a prevalent and recurrent urological disorder, commonly known as a kidney stone disease. It is widespread, ranging from 7-13% in North America, 5-9% in Europe, and 1-5% in Asia [18].

Continent	Prevalence
North America	7-13%
Europe	5-9%
Asia	1-5%

Table 1. The Prevalence of Nephrolithiasis

Symptomatic recurrence of second kidney stone episode was estimated and rated at 2, 5, 10 and 15 years and results are shown in Table 2.

Years	Symptomatic recurrence
2	11%
5	20%
10	31%
15	39%

Table 2. Symptomatic recurrence of kidney stone episode [19].

Recurrence depends on many factors like age, sex, race, genetic factors, type of stones, physical activity, energy intake or type of diet. Each patient has their own individualized risk which could be classified into modifiable, like life-style factors, and nonmodifiable factors [20]. Most patients describe renal colic as the most severe pain they have ever experienced, often seeking immediate care in the Emergency Room. Renal colic is characterized by a sudden onset of intense, acute pain that typically radiates to the pelvis, lower abdomen, or groin. Haematuria is also the common manifest of renal calculi [21]. In addition, patients often present systemic symptoms such as nausea, vomiting, fever or cold chills. In some cases, a positive Goldflam sign can be present on examination, which means costovertebral angle tenderness, but the occurrence of this is debated and discussed [22][23]. The diagnosis of kidney stones is based on symptoms, imaging tests and urine test. The fastest and easiest test to perform is abdominal or renal ultrasonography (USG) which identify renal stones with a sensitivity of 70% and a specificity of 94% [24]. Treatment usually includes thiazide diuretics, allopurinol, and citrate supplementation, but evidence suggests that eliminating renal calculi risk factors is also crucial. The first step should be to identify high-risk patients for whom dietary therapy is likely to be effective in reducing stone recurrence, and then implement the necessary changes to reduce their risk.[25][26][27][28].

Vegetarian diet - clinical significance

In recent years, the role of dietary patterns, particularly those which exclude meat, has garnered considerable attention in the context of nephrolithiasis prevention and management. Vegetarian diets, which are predominantly composed of plant-based foods such as fruits, vegetables, whole grains, nuts, and legumes, and exclude or limit animal products, have been associated with various health benefits, including reduced risks of hypertension, cardiovascular diseases, and certain types of cancer [29]. Evidence suggests that vegetarian diets may also influence the risk of kidney stone formation through multiple mechanisms. One of the primary mechanism by which vegetarian diets may reduce nephrolithiasis risk is through a lower dietary acid load, which is a result of reduced animal protein consumption. This dietary pattern leads to an increase in urinary citrate levels, an important inhibitor of stone formation, and a decrease in urinary calcium excretion, which is crucial for preventing calcium oxalate and calcium phosphate stones [30][31]. Furthermore, the high intake of fruits and vegetables in vegetarian diets contributes to higher urinary pH, which can inhibit the formation of uric acid and cystine stones [32]. Fruits and vegetables, foods which vegetarians eat considerably more often than omnivorous or standard diet, contain low protein and sodium chloride, and are high in potassium and magnesium. This contributes to a moderate alkalinizing potential due to anions like bicarbonate and citrate, which could explain some effects of fruit and vegetables on some of the most important urinary stone risk factors. High potassium intake has been linked to a lower risk of kidney stones, as it can boost citrate excretion in patients with idiopathic calcium stone disease. Additionally, potassium-rich foods can enhance magnesium excretion, another inhibitor of calcium crystallization, and reduce calcium excretion. They also help increase urine pH, which improves the solubility of uric acid, thereby having a favorable effect on kidney stone prevention. However, the relationship between vegetarian diets and kidney stones is not entirely straightforward. Certain plant-based foods, such as spinach, nuts, and beets, are high in oxalates, which can contribute to the formation of calcium oxalate stones, the most common type of kidney stone [33]. It is essential to balance oxalate intake with adequate dietary calcium to mitigate this risk, as calcium can bind to oxalate in the gut and reduce its absorption and subsequent urinary excretion [34]. Additionally, maintaining adequate fluid intake is crucial for diluting urinary solutes and reducing stone formation risk. [35]. Systematic reviews and studies have shown that vegetarian diets can have nephroprotective effects. For instance, they can improve renal parameters and reduce the risk of chronic kidney disease, which is associated with a higher risk of kidney stones . For example - lower urinary albumin–creatinine ratios, preserved kidney function and significantly lower urinary protein level in vegetarians. Reducing the amount of meat in the diet may also lower proteinuria [36][37]. The study performed in Asia renal function parameters was studied in 25 vegetarians compared with 25 non-vegetarians. A blood and urine sample from each subject was collected for renal function parameter determination. This include serum blood urea nitrogen (BUN), serum creatinine (Cr), and urine protein. A comparison of each renal function parameter between the vegetarians and non-vegetarians was performed using unpaired T-test. Statistical significant level was accepted at a p value ≤ 0.05. The averages (mean ± SD) of the studied renal function parameters of those with and without vegetarianism are presented in Table 3.

Of the studied parameters, it was found that urine protein was significantly different ($p < 0.05$) in vegetarian and controls. Concerning the other studied renal function parameters, although there is no significant difference, the trend of lower serum BUN and BUN/creatinine ration can be observed.

Renal function parametres	**Subjects with vegetarianism**	**Subjects without vegetarianism**	**p value**
Serum BUN (mg/dL)	9.8± 3.0	13.3± 2.0	>0.05
Serum creatine (mg/dL)	0.8± 0.3	0.9± 0.3	>0.05
Urine protein (mg/dL)	1.4± 0.6	5.2± 1.8	<0.05
BUN/Cr ratio	12.7± 5.4	16.2± 6.9	>0.05

Table 3. Average (mean ± SD) of renal function parameters in the subjects with and without low vegetarianism [38].

Conclusion

The pathogenesis of nephrolithiasis involves a complex interplay of genetic, metabolic, and environmental factors that contribute to the supersaturation of urine with stone-forming constituents, nucleation, crystal growth, aggregation, and retention of crystals within the renal system. Genetic predispositions, such as mutations leading to hypercalciuria and hyperoxaluria, and environmental factors, including dietary habits and hydration status, significantly influence the risk of stone formation. Understanding these multifaceted mechanisms is essential for developing effective prevention and treatment strategies. Future research should focus on elucidating the molecular and genetic bases of stone formation, identifying novel biomarkers for early detection, and developing targeted therapies to prevent recurrence and progression of nephrolithiasis. The integration of advanced diagnostic tools and personalized medicine approaches holds promise for improving patient outcomes in the management of kidney stones [39][40].

In summary, while a vegetarian diet may not entirely prevent renal calculi, it appears to reduce several risk factors associated with kidney stone formation. However, it's essential to ensure that such a diet is well-balanced and includes adequate hydration and appropriate calcium intake to maximize its protective effects.

Disclosures:

Author's contribution:

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All authors have read and agreed with the published version of the manuscript.

Funding statement:
The study did not receive special funding.

Institutional review board statement:
Not applicable.

Informed consent statement:
Not applicable.

Data availability statement:
Not applicable.

Conflict of interest:
The authors declare no conflict of interest.

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