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Chapter

Role of Dietary Supplements in Prevention of Renal Stones: An Update

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Abstract

Kidney stone disease is an oldest known and widespread medical condition characterised by its high prevalence in all over the world. Literature suggests that around 9–12% of population in industrialised countries have kidney stone disease in their lives with the 30–50% of reoccurrence rate. Because of high prevalence, recurrent and unpredictable nature of stone formation and its predominance mainly in adults contributes to the substantial impact on society, individual and health care system. In light of these trends, it's imperative to use optimum preventive strategies to reduce the burden of kidney stone disease on individual and society. The aetiology of kidney stone disease is a multifactorial and it's related to diet, environmental factors, genetics, metabolic syndromes and various life style factors. Its noteworthy that dietary and life style modification are the major contributors in the prevention of kidney stone reoccurrence. Dietary interventions aim to reduce the urinary abnormalities known to promote lithogenesis. Therefore, modification in the dietary factors is appealing way to patients and physicians in the treatment and prevention of stone recurrence as it is relatively inexpensive and safe. So, the present chapter is focusing on the role of dietary supplements in prevention of renal stones.

Keywords: kidney stones, dietary factors, prevention, health

1. Introduction

Kidney stone disease or renal calculi is a serious medical condition though not life-threatening disorder. In medical terms it referred as urolithiasis or nephrolithiasis where "Lith" meaning stone [1]. Renal stone formation is an oldest and widespread disease in the world affecting human beings. Its prevalence in the Europe is around 7–9%, Asia 1–5% and in North America 6–12%. The lifetime prevalence of renal stones in India is 5–11% [2]. This prevalence represents threefold increment and 5–6% absolute increment in last 20–30 years. Increased in the number of cases is reported in all groups irrespective of gender, racial and ethnic variation [3]. An alteration in normal mineral content of urine is the main cause for lithiasis [4]. Urinary components play a vital role in stone formation as they will be in their metastable state with several pre-existing substance which can crystalize to form calculi. These substances if exists in super saturation level makes urine unstable and will lead to crystallisation of excess of solutes [5].

Kidney stone may be found with different shapes, sizes and colours depending on their composition. Smaller stones may pass in the urine without any symptoms, but often stones grow in their size and develop a level of discomfort while passing through urine. In some case it may cause a severe pain if the surface of the stone is rough or it may require medical intervention as bigger stone cannot pass through the urinary system [6]. Other complications such as urinary tract infections, sever pain, or decline in the renal function may be associated with urolithiasis [7]. If neglected it may lead to the substantial damage to the kidney [6]. Since significant number of patients may have to undergo surgical interventions for the treatment, the management of the kidney stone has become considerably expensive [8]. Because of high prevalence, recurrent and unpredictable nature of stone formation and its predominance mainly in adults contributes to the substantial impact on society, individual and health care system [9]. In light of these trends, it's imperative to use optimum preventive strategies to reduce the burden of kidney stone disease on individual and society. Thus, awareness regarding importance of preventive measures particularly on consumption of healthy diet certainly help to reduce the cost of hospitalisation and will increase the compliance in general.

According to literature survey various preventive measures are available to reduce the risk of kidney stone formation such as life style modification, high water intake, less consumption of salt and modification in dietary habits. As diet has shown its strong association with stone formation, changes in dietary habits may help to reduce the burden of stone formation. Less awareness on effect of food on stone formation is one of the main reasons for increase prevalence. So, more studies have to be focused effect of various diets at molecular level to understand the actual mechanism behind stone formation. Thus, present chapter is focusing on role of various diets in prevention of kidney stone disease.

2. Types of kidney stones

Chemical constitutes of urine is the main factor for variation in chemical composition of the stones. These variations may be associated with other risk factors such as environmental factors, diet, climate and life style habits. Based on this, urinary stones can be classified in to five major classes.

- **Calcium stones:** Calcium stone can exist as calcium oxalate or calcium phosphate or calcium carbonate. Among all the types these are the prominent ones constituting around 70–80% of the total stone forms. Calcium oxalate can exist as calcium oxalate monohydrate (COM) or dihydrate (COD). COM is the more stable form and common compared to the COD. Various factors may contribute to calcium stone such as hypercalciuria, hyperoxaluria, hyperuricosuria etc. [10].

- **Uric acid or urate stones:** Uric acid stone accounts approximately for 5–10% of all the types of stones. High purine content of diet such as animal protein is main risk factor for the formation of uric acid stone. Other risk factors are low urine volume, hyperuricosuria, and low urinary pH [11].

- **Magnesium ammonium phosphate stones or struvite stone:** Also called as infection stones or triple phosphate stones. These stone occur at the extent of 12–15%. The main cause for the struvite stone is urinary tract infections where

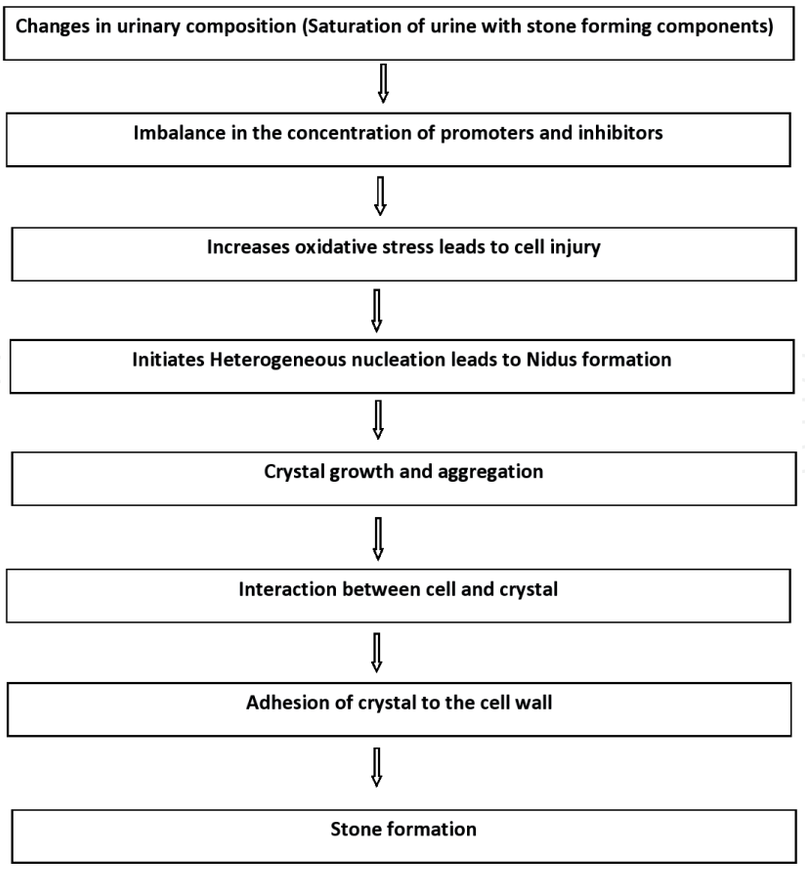


Figure 1.
Steps for mechanism of stone formation.

urease produced by microbes split urea into ammonia and carbon dioxide. This makes the urine alkaline and makes phosphate insoluble at its high pH. Thus, phosphate gets precipitated on the ammonia leading to the stone formation. Its more common in female compared to male [12].

- **Cystine stones:** The occurrence of cysteine stone is less than 3% among all the types of the stones. It occurs as a genetic disorder with defect in cystine amino acid transportation, which results in excess excretion of cystine in urine referred as cystinuria. It is an autosomal recessive disorder resulting in impaired renal tubular absorption of cystine and excretion of cystine in urine. As cystine is insoluble in urine results in the formation of stones in kidney [13].

- **Drug-induced stones:** These stone accounts for only 1% of total stones. Drugs such as triamterene, atazanavir, and sulfa drugs induce stone formation. Lithogenic drugs and their metabolites may get deposited to form nidus or on already existing stone. Some drugs may also interfere in purine and calcium oxalate metabolism and may lead to the stone formation (**Figure 1**) [14].

3. The aetiology of kidney stones

The aetiology of kidney stone formation is multifactorial. There are various risk factors associated with formation of kidney stones such as age, gender, ethic and family background, life style habits, environmental variations, occupation

and dietary habits. Variations in these risk factors initiates super saturation of urine which may cause changes in the morphology of kidney, change in urine flow, urinary tract infections and metabolic abnormalities (**Figure 1**) [1].

- **Age:** The most vulnerable group for the urolithiasis is 20–60. The incidence of kidney stones is increased with age, thus middle-aged people are very prone to get kidney stone disease [15]. One of the most common reason which could be related to this age group is less fluid intake, dehydration, stress at the work place and unhealthy life styles. In some population the age distribution is different in males and females; male is affected after the age of 60 whereas females are affected at the age of 45–50 [16].

- **Gender:** According to most of the literature survey kidney stone disease is more common in males compared to female with the ratio ranging from 1.5 to 5. It may be associated with the changes in the dietary habits and testosterone promote the stone formation in males [17]. However, in recent decades this ratio is narrowed in many countries, which says that even females are more affected and prevalence is increase in both genders. The main reason for this could be standard living habits, high calorie food consumption and variations in occupations [18].

- **Climate:** Geographic and climatic changes are one of the major risk factors for urolithiasis, specifically temperature, seasonal variations, atmospheric pressure, humidity. High prevalence is seen in tropical and subtropical countries than in frigid zones. Considering seasons incidence will be high in summer compared to spring and winter. This may be associated with the concept of higher temperature leading to loss of water through the body fluids and dehydration which may lead to excretion of concentrated urine may become cause for formation of stone [19].

- **Dietary habits:** Diet also plays an important role in formation of stones in kidney. Diet rich with high amount of oxalate is the main precursor for stone formation. In addition, diet containing high amount sodium, protein, calcium also acts as risk factors for stone formation. This is the main reason for the raising trends of kidney stone disease in many of the Asian countries [20]. Oxalates present in the food gets metabolised in liver and Calcium in intestine combine with excess of oxalate and lead to formation of insoluble calcium oxalate stone [21]. Excessive consumption of animal meat will lead to increased uric acid concentration and results in hyperuricosuria, is the main risk factor for the uric acid stone formation. In addition, pH of the urine plays an important role in lithiasis as appropriate pH favours crystal precipitation, initial step of stone formation [22, 23]. Along with diet less fluid intake is also a main cause for stone formation. Water with high fluoride content may also become risk factor for stone formation. The fluoride in the intestine favours the absorption of oxalate and promotes excess of oxalate excretion and formation of calcium fluoride in urine [24]. Excretion of high concentration of magnesium in urine is also one of the causes for stone formation in kidney [25]. On other hand one of the studies conducted by Chandrajith et al., have not found any association between hardness of water and urolithiasis [26].

- **Occupation:** According to studies conducted on stone formation and occupation, sedentary life style is one of the risk factors for urolithiasis. Some studies reports that there is a positive association between more physical work and

kidney stone disease. The risk of kidney stone formation is more in case of people expose to the sunlight or high temperature for longer period like farmers, miners' drivers etc. than people working at room temperature [27]. People working in these conditions may consume less fluid and they will be more prone to have dehydration, which may lead to excretion of concentrated urine and lead to urolithiasis. However, there are some studies which have shown negative relation between stone formation and occupation [28].

- **Genetics:** Genetic factor also contribute to the renal stone formation, especially cysteine stones are formed by mutation in the gene SLC3A1 and ALC7A9. In addition, even in case of uric acid stones some mutations seen in SLC2A9 and SLC22A12. In some cases, calcium oxalate stones are formed because of the deficiency of enzymes such as glyoxylate reductase/hydroxy pyruvate reductase (GRPHR), alanine glyoxylate aminotransferase. As a result, synthesis and excretion of oxalate is increased leading to calcium oxalate stone formation [29].

- **Racial distribution:** The association of kidney stone disease with different racial background is still controversial. In Asian population the association is been reported by certain studies. Whereas studies conducted in Iran have not shown a significant association between racial difference and prevalence of urolithiasis. In general terms, dietary habits, life style changes and gene of various races are the main key factors for the variations [30, 31].

4. Importance of diet

Intake of healthy and fresh diet plays an important role in maintaining the health status of human kind. Balanced diet has been immensely accepted all over the world owing to the increased awareness regarding the maintenance of health status among people. Balanced diet is comprised of all essential nutrients, which are required for good health of human beings [32]. Nutrients present in food provides energy to perform vital functions of life and also helps for growth and differentiation of cells. These nutrients can be classified into micro nutrients and macro nutrients based on the requirements. Micro nutrients are the one which are requited in a smaller quality which includes vitamins and minerals whereas macro nutrients are the one which are required in a larger quantity which includes carbohydrates, lipids and proteins [33]. All these nutrients are present in the food materials like cereals, pulses, vegetables, fruits, meat and dairy products. Among these products high amount of protein is found in meat. The concentration of protein may vary in different kind of animal meat like beef, mutton, chicken fish etc. whereas carbohydrate will be present in cereals, potatoes, milk and lipids will be rich in nuts, peanuts, ghee, oil, butter etc. [34].

5. Variations in the dietary habits

Variation in food habits arises from the people's origin and it is modified by resource of the respective place or origin. The major resources having impact on the food culture are climate, Land, soil, water, cultural and religion of the habitat [35]. The era of globalisation has changed the eating and life style habits which has shown a very strong impact on the health of human beings. Urban areas of most of the countries, have embraced more processed and packed food, which have led

to increased obesity and body mass in people. Diversified food habits have been seen in various parts of the world and also within the countries itself with different geographical areas. These food variations are the main factor for variations in prevalence for urolithiasis at different geographical places [35].

6. Role of dietary habits in stone formation

Among various risk factors of urolithiasis, food is considered as one of the important modifiable risk factors in the kidney stone disease. According to the study conducted by Maalouf et al. [36] states that a load of protein diet in food will lead to increased calcium excretion. This may lead to increased risk for kidney stone formation. High amount of protein diet induces acid load in the body because of production of protons during the metabolism by sulphur containing amino acids and also there will be increased calcium excretion followed by high protein diet [36]. In addition to this high intake of animal protein leads to increased concentration of calcium, oxalate, uric acid and phosphorus in the urinary tract. There are various mechanisms involved which may lead to increased concentration of these substances in the urine and may lead to the formation calculi [37]. High intake of carbohydrates and lipids also have shown similar effects on the urinary composition. Furthermore, less intake of fruits and vegetables may also act as risk factor for urolithiasis even though some of them will be rich in oxalates [38]. High intake of sodium in the form of excess of common salt is noticed in case of many industrialised countries lead to more calcium deposition in kidney. The role of magnesium and vitamin C in the kidney stone formation is still not clear. Few studies have reported with no significant association with stone formation, whereas the effect of these nutrients on urinary composition shows its role in urolithiasis [39]. Thus, most of the studies support the fact that there is a relation between dietary habits and kidney stone formation, although contradictory results are also available.

Different food items	Content of food	Role in urolithiasis	Reference
Milk, cheese, dark green vegetables, yogurt, calcium fortified beverages etc.	Dietary calcium	Decreases the risk of calcium oxalate stone formation	[40]
White meat poultry, lean beef, eggs, beans, etc.	Protein	High load of acid in the kidney increases risk of kidney stone formation Increase urinary excretion of calcium	[41]
Canned food, corn meal, Black eyed beans, beets etc.	Sodium	High level of urinary calcium	[42]
Green leafy vegetables, beets, berries, chocolates, cranberries	Oxalate	Increased oxalate absorption from the intestine lead to high amount of excretion	[40]
Citrus fruits, peppers, strawberries, blackcurrants, broccoli etc.	Vitamin C	High oxalate excretion in urine	[43]
Energy drinks, soft drinks, carbonated drinks, coffee etc.	Carbonated beverages	High level of oxalate excretion in urine	[44]

Table 1.
Role of various food stuffs on kidney stone formation.

In the present chapter we are discussing in detail about the role of diet in KSD, so that we could summarise important preventive dietary habits for the urolithiasis (**Table 1**).

7. Impact of fluid on urolithiasis

Less fluid intake is one of the major risk factors in the stone formation, whereas adequate amount of urine excretion will eventually reduce the saturation of urine. To achieve 2 L/day of urine excretion fluid intake should be higher at the range of 2–3 L/day as water will be lost for extra renal functions like sweating, breathing and perspiration [45]. Along with volume of fluid intake, the quality and composition of fluid or water is also equally responsible for stone formation and it can be considered as a modifiable risk factor. Many studies have reported that high amount of fluid intake will eventually reduce the risk of urolithiasis [46].

Apart from water, other beverages like soda, tea, coffee and aerated or carbonated drinks consumption will also be having their impact on stone formation. High intake of sugar sweetened soda rich with fructose increases the risk of urolithiasis, as fructose promotes synthesis of uric acid and increases the excretion of uric acid, calcium and oxalate in urine [47]. Fructose rich food, makes the cells to utilise excess ATP for its uptake and such monosaccharides reduces phosphate concentrations within the cells and induces production of uric acid which leads to hyperuricosuria. So, in hyperuricosuria patients, it's advisable to reduce the intake of fruits, beverages and fruit juices rich with fructose content [48]. Another study conducted by Shuster et, al. reported that intake of carbonated/aerated beverages is also one of the risk factors for formation of calculi as these beverages contains high amount of phosphoric acid [49]. On the contrary some studies also evidenced that citric soda content of the aerated drinks has a capacity to reduce the risk of stone formation by increasing the excretion of citrate. However low energy aerated drinks have not shown significant association in large cohort studies, suggesting that more than carbonated content fructose content of the drinks is the main culprit for urolithiasis [50]. A study conducted by Ferraro et al. [51] reports that beverages such as tea, coffee reduces the risk of calculi formation as studies have noticed that caffeine intake is associated with increased urinary output. Still excess consumption of tea, coffee is not advisable as it may interfere with other metabolic reactions which influence changes in the blood pressure**.** Hot beverages such as beer, alcohol have shown controversial results for their association with stone formation. In the study conducted by Ferraro et al., these drinks have shown to reduce the risk of stone formation as they reduce the activity of antidiuretic hormone and helps to excrete excess amount of diluted urine [51]. In contrast to this, a study conducted by Borghi et al. reports that alcohol intake should be avoided in case of urolithiasis patients as it will be rich in purine and it may cause hyperuricosuria [46]. Another study conducted by Rodgers et al., found that magnesium and calcium content of mineral water acts as protective in case of calcium oxalate stones [52]. Studies conducted on effect of various fruits juices have shown its impact on stone formation. Fresh lemon juice involved in the excretion of citrate and reduces excretion of calcium in urine. In concern with non-citrus fruits the results of the studies are still controversial as some fruits have shown beneficiary effect whereas some have not shown any significant association with urolithiasis [53]. Thus, these studies suggests that all fluids are not having same effect on urolithiasis. So, it's advisable to reduce the intake of sweetened beverages and high citrate content drinks as they have shown unfavourable outcomes in KSD patients.

8. Effect of carbohydrate diet on urolithiasis

A study conducted by Nouvenne et al. reports that high carbohydrate food intake has shown increased excretion of calcium in urine compared to healthy individuals because carbohydrates decrease the calcium reabsorption in the renal tubules [54]. In contradictory to this some studies have reported that increased glucose concentration in diet has enhanced the calcium absorption in intestine. Various epidemiological studies have been conducted to find out the relation between insulin action and calculi formation specifically with uric acid stones. The insulin renal receptors show imbalance in acid handling which results in impaired excretion of ammonia in urine leading to excretion of acidic urine which favours precipitation of uric acid crystals leading to uric acid stones. This could one of the main reasons for high prevalence of urolithiasis in metabolic syndrome cases [55]. In addition to this high fructose intake has shown a strong association with formation of kidney stones as it enhances excretion of citrate and calcium in urine which favours the formation of stones in kidney. Increased fructose intake may cause insulin resistance and it may become trailing step for the formation of uric acid stone as it decreases the urinary pH and lead to uric acid stone formation [56]. Another study conducted by Curhan et al. reports that intake of sucrose has also shown its association with stone formation as high sucrose may increase the urinary excretion of calcium which is not dependent on the calcium intake (**Figure 2**) [57].

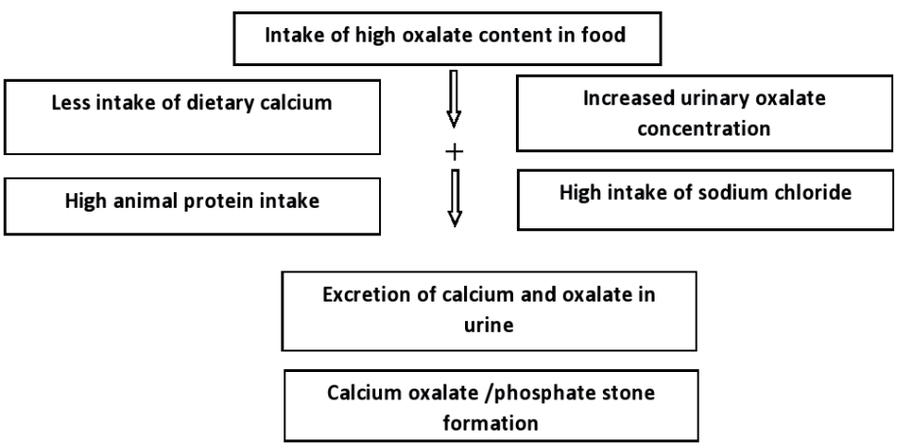


Figure 2.
Effect of various food items in calcium oxalate/phosphate stone formation.

9. Effect of protein diet on urolithiasis

Various studies have shown a strong association of protein intake specifically animal protein with kidney stone formation. Animal protein will be rich in purines and after its degradation it produces uric acid [58]. These contains amino acids such as tyrosine, tryptophan and glycine and degradation of these amino acids produces oxalate which is the main component of calcium stones [59]. Increased oxalate content causes calcium and citrate resorption, renal acid excretion and increased urinary excretion of calcium which ultimately cause kidney stones [60]. Animal protein such as meat, poultry, fish shows unfavourable effect as their intake leads to uricosuria, calcinuria and phosphaturia and also reduces urinary pH. All these conditions increase the risk of precipitation of substances like calcium and uric acid and lead to calculi. Formation [61]. According a study conducted by Kerstetter et al. reports that in a normal healthy individual for every 20–25 g of increase in dietary animal protein, will rise the urinary calcium by

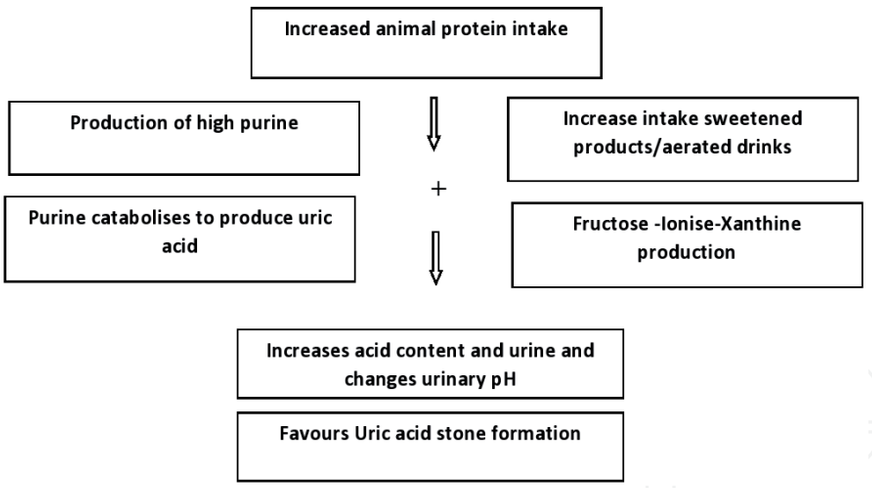


Figure 3.
Effect of various food items in uric acid stone formation.

30–35 mg/day [62]. The final outcome of high animal protein intake by keeping volume of the urine constant is super saturation of urine with calcium oxalate and uric acid which are the main risk factors for stone formation. The underlying mechanism for uricosuria and phosphaturia is related to high content of these substances in animal protein. In addition to this increased calcinuria and change in urinary pH is mainly attributed by sulphureted amino acids such as methionine and cysteine which produces hydrogen ions leading to subclinical acidosis [63]. The reason for oxaluria is still not clear yet according to studies conducted, presence of oxalate in animal proteins produced by amino acids such as tryptophan, tyrosine increases endogenous production of oxalate which may create favourable environment for formation of stones [64]. Its notable that effect of vegetable proteins on urinary composition is different from those of animal proteins**.** A study conducted by Breslau et al. [65] observed that intake of exclusively vegetarian diet with vegetable proteins leads to less excretion of calcium, phosphate and more oxalate, citrate in urine with less acids as vegetable proteins contains different quantity of sulphates, purines, oxalates and fibres. On a whole, this suggests that vegetable proteins are less harmful for urolithiasis specifically in context with uric acid stones (**Figure 3**) [65].

10. Effect of lipid diet on urolithiasis

According to some observational studies there is an association between lipid intake and stone formation in kidney. A study conducted by Khan et al. [66] observed significant changes in the concentration of lipids in urine among stone formers and healthy individuals. The altered lipid content in the membrane enhances nucleation and retention of calcium oxalate crystals which are the initial steps of calculi formation [66]. Another study conducted by Naya et al. [67] reported that there is a relation between urinary lipids and crystal formation as it correlates with urinary oxalate excretion. This association is more evident in case of arachidonic acid content of diet as it increases absorption of oxalate from intestine and increases its clearance from kidney [67]. Another study conducted by Baggio et al. also supports these results as they evidence a high concentration of arachidonic acid in red blood cell membranes and plasma of urolithiasis patients [68]. Still some contradictory studies are also available which says that there is no correlation between lipid diet and urolithiasis [69].

11. Effect of milk and milk products on urolithiasis

The requirement of calcium to body is satisfied by calcium rich food stuffs such as milk (100–120 mg/dl), cheese (approx. 500–600 mg/100 g) and yogurt (approx. 100 mg/100 g). The amount of calcium intake affects the level of calciuria in kidney stone patients and also in healthy individuals. Specifically, the absorption of calcium will be on higher side in kidney stone formers. This is suggesting that increasing in dietary calcium intake than its normal range have its impact on calcium stone formation. This was considered to be a risk factor for many ears and physicians used to suggest to avoid calcium rich food in urolithiasis patients [70]. But according to most of the recent research work, the dietary calcium is no longer involved in formation stone as reduction in the dietary calcium did not show its impact on reduction of calciuria [71] and avoiding dietary calcium may lead imbalance in calcium concentrations and cause certain complications like osteoporosis or osteopenia over a long period. In addition to this when there is a restriction on dairy products, patients may compensate its protein by consuming high quantity of animal protein which may show its own complications in long terms [72]. According to the results of most of pathophysiological studies reported so far, the risk of stone formation is less in subjects who consume high quantity of calcium than in those people who consume less amount of calcium irrespective of gender. A randomised study carried out over 5-year period reports that intake of less calcium diet by reducing milk related products is less significant in preventing calculi reoccurrence than a normal calcium intake with low animal protein diet. Hence, in view of these results it's necessary to understand that no idiopathic stone formers should be advised for less intake of milk and milk product which may lead to complications because of hypocalcaemia [73].

12. Effect of sodium chloride and potassium on urolithiasis

A significant relation between calcium stone formation and salt intake was first showed in a cohort study conducted by Curhan et al. [74]. Some studies conducted in further years did not succeed in confirming these results. A study conducted by Sabto et al. reports that daily intake of around 20–25 mmol of sodium will increase the calcium excretion in urine by 0.5–0.7 mmol/day, thus suggesting greatest impact of sodium on urinary calcium [75]. Salt present in the food stuff inhibits the tubular reabsorption of calcium thus leading to increased excretion of calcium in urine. In addition to this sodium chloride also inhibit the excretion of citric acid in urine, which is one of the significant risk factors for urolithiasis. The mechanism by which sodium decreases citric acid levels in urine is still unclear [76, 77]. Although there are no studies available to prove the fact that less sodium chloride intake will decrease the risk of calculi formation, but there are some studies which reports that beneficiary effect of low animal protein can be enhance by taking less sodium chloride. A well-balanced diet is with only required amount of sodium chloride will eventually help in preventing renal calculi [73]. Along with sodium even potassium is also involved in regulation of urinary calcium in human body. According to a study conducted by Muldowney et al., potassium deprivation was associated with increased calcium excretion in case of healthy individuals with normal diet with normal content of sodium chloride [78]. Another study conducted by Knight et al. also noticed in their study that sodium and potassium are involved in increasing urinary pH and its volume which are initial stages of cysteine stone formation [79].

13. Effect of fruits and vegetable on urolithiasis

The role of fruits and vegetables in kidney stone formation is always been a controversial as these have shown both beneficial effects as well as harmful effects in case of Kidney stone disease. As fruits and vegetables are one of the important dietary sources of oxalate and this absorbed oxalate will be excreted in urine. If urine gets saturated with oxalate content it may become a risk factor for urolithiasis but however this oxalate is not withstanding [80]. Whereas there are some studies which have shown beneficiary effects of fruits and vegetables on urolithiasis as they contain high amount of magnesium and potassium and less amount of animal protein and sodium chloride. In addition, some fruits and vegetables also give alkaline therapy to the urine composition with their high content of bicarbonate and citric acid [81]. So it's important to note that not all the vegetables and fruits are harmful for urolithiasis as very few will be rich in oxalate such as spinach, beets, nuts wheat bran etc. which significantly results in oxaluria [82]. Along with effect of dietary oxalate content, the absorption rate of oxalate may vary person to person, as a study conducted by 80 showed that around 9–12% of idiopathic urolithiasis patients have shown increased oxaluria because of their increased intestinal absorption rate by 15–30% [83]. Another study conducted by Lemann et al. [84] reported that intake of fruits and vegetables can enhance magnesium excretion which is one of the important inhibitors for calcium crystallisation. And also favours the dissolution of uric acid by changing pH of urine [84]. By considering all above-mentioned factors, we suggest physicians to recommend intake of fruits and vegetable in their day today life to all the type of stone formers with a note of restricting foods having increase oxaluric activity to avoid calcium oxalate stone formation. Elimination of fruit and vegetables from diet of normal subjects causes unfavourable changes in urinary composition and may become risk factor for stone formation as their deficiency may significantly increase in super saturation of urine for calcium oxalate and calcium phosphate [85]. Considering above mentioned facts, we encourage physicians to advise their patients to consume fruits and vegetables regularly with restriction of vegetables showing hyperoxaluric effect to avoid increment in urinary oxalate content.

14. Effect of vitamins on urolithiasis

The role of vitamins in the formation of stone is still uncertain. But according to literature review, vitamins with higher risk of causing urolithiasis are ascorbic acid (vitamin C), pyridoxine (vitamin B6) and calcitriol (vitamin D). A study conducted by Broadus et al., reported that the subjects with increased calcium excretion had high levels of vitamin D in their blood sample which lead to increased absorption of calcium in the intestine. Excluding some special cases, it's not suggestible to give supplementations of vitamin D particularly with combination of calcium to kidney stone patients [86]. High intake of vitamin C (ascorbic acid) has become a widespread practice all over the world as ascorbic acid helps in wound healing and preventing degenerative diseases. Vitamin C is a precursor of oxalate and it may increase excretion of oxalate in urine which a risk factor for calculi formation [87]. Intake of vitamin C around 1300–1500 mg/day is acceptable, if intake increases more than 1500 mg/day it will lead to initiation of crystal formation in urine [88]. Among vitamin B complex Vitamin B6 paly a vital role in reduction of risk of stone formation. Vitamin B6 (Pyridoxine) involves in the metabolism of oxalate, so deficiency of pyridoxine may lead to increased production of

endogenous oxalic acid. Intake of Vitamin B6 around 40–50 mg/day in diet will eventually help to reduce excretion of oxalic acid in urine and reduce the risk of urolithiasis [89, 90]. In a summary, with regards to vitamins adequate amount of all the vitamins should be consumed through the diet as they a play important role in metabolism of vital biomolecules and also helps to maintain good health status of an individual. Kidney stone patients should avoid excess in take of ascorbic acid, and vitamin D supplementations as these have been reported as risk factors for urolithiasis. The patients can be advised to take good amount of pyridoxine as it is considered to reduce the risk of stone formation.

15. Conclusion

The prevalence of kidney stone disease has increased in recent years as a result of modification in eating and life style habits. Changes in urinary composition and urinary saturation is the initial step for stone formation. So, focusing on reducing urinary saturation may help to reduce the initiation of urolithiasis. Various preventive measures are available which could reduce the burden of stone disease. Among all, dietary interventions show promising results in reducing the risk of stone formation as diet shows its direct impact on urinary composition. Among various types of stones, the most prominent stones such as calcium oxalate/phosphate and uric acid stones shows direct association with diet. According to our review of literature diet containing animal protein will increase urinary uric acid concentration which favours the uric acid stone formation. Diet with high oxalate content will increases urinary oxalate and combine with calcium to form calcium oxalate stones. Less fluid intake is one of the major risk factors for urolithiasis as fluid will help to dilute urine and reduce the saturation of urine. Considering these facts avoiding the foods with increased risk of stone formation and consuming balanced diet in kidney stone formers will help to reduce the reoccurrence and eventually help to reduce the prevalence of disease.

16. Summary

Urolithiasis is a highly prevalent disease with its increased rate in recent years across the world. A change in food habits and intake of high calorie food is one of the main reasons for increased prevalence of kidney stone disease. The main aim of focusing on dietary interventions is to reduce urinary lithogenic risk factors such as increased calciuria, uricosuria, phosphaturia and low urinary pH. According to literature survey it's advisable to cut down high intake of animal protein and excess salt intake as animal protein increases uric acid concentration in urine and salt will increase mineral content of urine. Intake of high calorie food should also be reduced as it's involved in increasing saturation of urine and it may also lead to other health complications such as metabolic syndromes. High intake of aerated or carbonated drinks should be avoided in kidney stone formers as they contain high amount of sugar (Fructose). Along with reduction in consumption of above-mentioned food items it's equally important to consume food items which helps to alkaline the urine and reduce the risk of stone formation. According the literature survey it's advisable to consume good amount of green leafy vegetables with less oxalate content. Adequate amount of vitamins have to be taken in diet as their absence may lead to some deficiency manifestations in an individual. Excess consumption of vitamins such as vitamin D and C should be avoided as they may increase the risk of stone formation. In addition to diet, intake of high quantity of water will help to dilute

the urine sample and reduce urinary saturation. As some food items still shows contradictory results on stone formation, so more studies have to be conducted in this regard considering higher population in order to establish the relation of these food items in stone formation which will eventually help to reduce the burden of stone formation.

Funding

None.

Conflict of interest

The authors declare conflict of interest as none.

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