The association of dietary inflammatory index with urinary risk factors of kidney stones formation in men with nephrolithiasis

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Research note

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Abstract

Objective: Inflammation plays a leading role in the pathogenesis of nephrolithiasis. The association of the dietary inflammatory index (DII) with urinary lithogenic factors is unclear. This study aimed to evaluate the relation of DII to urinary risk factors of kidney stones formation.

Results: Of 264 participants, 61.4% (n= 162), 72% (n=190), 74.6% (n=197), 68.6% (n=181), and 80.3% (n=212) had hyperoxaluria, hypercreatininuria, hypercalciuria, hyperuricosuria, hypocitraturia, respectively. There was a significant increasing trajectory in urinary calcium, uric acid, and creatinine as well as a decreasing trend in urinary citrate across tertiles of DII score (all P=≤0.001). After multivariate adjustment for energy intake, age, physical activity and body mass index, high DII scores were associated with elevated odds of having hypercreatininuria (OR=2.80, 95%CI: 1.10-7.12, P_{trend}=0.04), hypercalciuria (OR=7.44, 95%CI: 2.62-21.14, P_{trend}≤0.001), hyperuricosuria (OR=2.22, 95%CI: 1.001-4.95, P_{trend}=0.05), and hypocitraturia (OR=5.84, 95%CI: 2.14-15.91, P_{trend}≤0.001). No association was identified between DII and hyperoxaluria.

Introduction

Nephrolithiasis, also known as kidney stones, is one of the most prevalent urologic disorders and impose a substantial burden on human health globally [1]. The high recurrence rate of kidney stones, with about 50% over a period of 5–10 years and more than 90% within 30 years is yet unsolved [8 9], mostly due to the lack of suitable management of the associated risk factors. Thus, there is an urgent need to target modifiable risk factors to prevent the development and recurrence of renal stones.

Cumulative data have identified that higher urinary excretions of oxalate, calcium, creatinine, and uric acid as well as lower excretions of citrate are potential modifiable urinary lithogenic risk factors involved in the formation of kidney stones [10–12]. Inflammation is also another mechanism which plays a leading role in the pathogenesis of nephrolithiasis [13]. Main biomarkers of inflammation are detectable in the urine of these patients [14]. In the presence of abnormal urinary oxalate, citrate, calcium, and uric acid, there is an overproduction of reactive oxygen species and a reduction in the antioxidant capacity, which results in oxidative stress, inflammation, and kidney injury [13]. Dietary modifications toward decreasing inflammation may have a potential to prevent kidney stones or their recurrence. Previous studies have shown that several micronutrients or foods such as magnesium, vitamin E, vitamin C, carotenoids, polyphenols, polyunsaturated fatty acids (PUFAs), whole grains, vegetables, fruits, and fish had an anti-inflammatory impact [15–18]. In contrast, simple sugars, red meats, high-fat dairy products, and refined grains are associated with elevated inflammatory markers [19]. Nevertheless, nutrients or foods are not consumed separately but as part of the whole diet [20–22]. The Dietary Inflammatory Index (DII) is developed to measures the overall inflammatory potential of diets [23], which has been recognized to be related to the biomarkers of inflammation, including interleukin-6 [24], homocysteine [25], and C-reactive protein (CRP) [26]. A proinflammatory diet has been found to be related to the reduced kidney function [27]. However, there is no study investigating the relation of DII to urinary lithogenic factors.

Therefore, this study aimed to assess the association of DII with hypercalciuria, hypocitraturia, hyperoxaluria, hyperuricosuria, and hypercreatinuria in patients with nephrolithiasis.

Methods

Subjects

This cross-sectional study was performed on a total of 264 stone former men (aged 18–89 years) in Tehran, Iran in 2016. Participants were recruited from the Urology Research Center of Sina Hospital, Tehran, Iran, using a convenience sampling method. Inclusion criteria for this study were having a history of kind stone formation and age ≥ 18 years. People with a history of, thyroid disease, fatty liver disease, malignancy, stroke, diabetes, cardiovascular disease, and hypertension were excluded from the present study because of the possible change in their dietary pattern. Participants who had missing data regarding dietary intake in food frequency questionnaire (FFQ), those with unlikely total daily energy intake (< 500 kcal/day and > 4200 kcal/day), and those who were on medications such as corticosteroids, diuretics, anti-cancer drugs, multivitamins, potassium citrate, calcium, and vitamin D or C supplements were not eligible for this study. Furthermore, all alcohol drinkers and drugs abusers were excluded. Patients were included in the study after signing written informed consents. Ethics approval for the study protocol was granted by The Human Ethics Committee of Tehran University of Medical Sciences (ID: IR.TUMS.VCR.REC.1395.1046).

Dietary assessment

Usual food intake of patients during the previous year was measured by an interviewer-administered validated semi-quantitative 168-item food frequency questionnaire) FFQ([28]. In this study, DII was calculated using the method reported by Shivappa et al. [29]. The DII score was calculated with the use of the corresponding 32 nutrients or food parameters available from the FFQ, including energy, protein, total fat, carbohydrate, dietary fiber, mono-unsaturated fatty acids, n-3 fatty acids, n-6 fatty acids, poly-unsaturated fatty acids, saturated fatty acids, cholesterol, trans fatty acids, vitamin A, thiamin, niacin, riboflavin, Vitamin B-6, folate, vitamin B-12, vitamin E, vitamin C, Vitamin D, b-carotene, iron, magnesium, zinc, selenium as well as caffeine, onion, green/black tea, paper, and garlic. The overall DII score for each individual was calculated by summing food item-specific DII scores [29]. Higher DII scores indicate a more pro-inflammatory diet, while lower DII scores indicate a more anti-inflammatory diet.

Measurements of study outcomes

The 24-h urine samples were collected from all participants and urine was analyzed to evaluate urinary levels of calcium, citrate, creatinine, oxalate, and uric acid by using an AutoAnalyzer. We measured urine creatinine with the use of the Jaffe technique, which as an enzymatic colorimetric method without removal of proteins. Uric acid concentrations were assessed by an enzymatic colorimetric technique. Urinary calcium concentrations were measured with the use of quantitative detection kits for cresolphthalein complex and photometric technique. Furthermore, spectrophotometry method was

applied to determine the concentrations of citrate and oxalate. Hyperoxaluria was defined as the urinary oxalate 40 mg/dL, hypocitraturia as urinary citrate values of < 450 mg/dL, hyperuricosuria as urinary uric acid over 0.8 g/dL, hypercreatininuria as urinary creatinine values of 24 mg/dL, and hypercalciuria as a urinary calcium concentrations ≥ 250 mg/dL [30].

Measurement of other variables

Information on education level, age, marital status and occupation was obtained using interview by a trained interviewer. Physical activity was measured using of the International Physical Activity Questionnaires (IPAQ) [31]. Body weight was measured in minimal clothing after removal of shoes by a digital scale (Seca, Germany) with a precision about 0.1 kg. Height of individuals was assessed in standing position, without shoes, using a calibrated stadiometer (Seca, Germany) to the nearest 0.1 cm. BMI was calculated as weight divided by the square of height (kg/ m2).

Statistical analyses

DII was categorized into tertiles: T1 (− 3.72 to − 0.74); T2 (− 0.73 to 0.92); T3 (0.93 to 3.99). Analysis of variance (ANOVA) and chi-square tests were used to compare continuous and nominal/ordinal variables across tertiles of DII, respectively. Continuous variables are reported as mean ± SE and nominal/ordinal variables as frequency. Odds ratio (OR) and 95% confidence interval (CI) for the relation of DII to study outcomes was calculated using the logistic regression analysis. In addition to the crude analysis, two models of adjustment were fit: (1) minimally adjusted: energy intake and (2) multivariable-adjusted: energy intake, body mass index (BMI), physical activity, and age. Statistical significance was set at $p \leq 0.05$ for all tests. All analyses were undertaken using the statistical Package for Social Science (Version 22.0; SPSS Inc., Chicago IL, USA).

Results

A total of 264 men participated in this study and all completed the investigated measurements. The mean age and BMI of the included subjects was 42.68 ± 0.78 years and 26.75 ± 0.24 kg/m2, respectively. Of 264 participants, 61.4% (n = 162), 72% (n = 190), 74.6% (n = 197), 68.6% (n = 181), and 80.3% (n = 212) had hyperoxaluria, hypercreatininuria, hypercalciuria, hyperuricosuria, hypocitraturia, respectively. Participants in the highest tertile of the DII had significantly higher total daily energy intake (P = ≤ 0.001) and lower physical activity (P = 0.01) than those in the other tertiles. There was a significant increasing trajectory in urinary calcium (P = ≤ 0.001), uric acid (P = ≤ 0.001), and creatinine (P = ≤ 0.001) and a decreasing trend in urinary citrate (P = ≤ 0.001) across tertiles of DII score. No significant differences were observed in urinary oxalate, anthropometric indices, and socio-demographic status of participants according to the categories of DII (Table 1).

Table 1
Characteristics of the study participants across tertiles of the DII score.

	Total	**Dietary inflammatory index score**			
	N = 264	**Tertile 1 (n = 88)**	**Tertile 2 (n = 88)**	**Tertile 3 (n = 88)**	**p-value**
Age (year)	42.68 ± 0.78	41.58 ± 1.31	43.83 ± 1.38	42.64 ± 1.37	0.50
Height (cm)	173.52 ± 0.47	173.18 ± 0.78	173.56 ± 0.86	173.81 ± 0.84	0.86
Weight (kg)	80.73 ± 0.86	80.93 ± 1.60	81.36 ± 1.51	79.92 ± 1.39	0.78
BMI (kg/m2)	26.75 ± 0.24	26.94 ± 0.47	26.93 ± 0.42	26.37 ± 0.37	0.55
Physical activity score	4851 ± 453	6654 ± 991	3413 ± 669	4486 ± 611	0.01
Energy intake (kcal/day)	2435.86 ± 35.44	2205.91 ± 44.04	2380.07 ± 59.24	2721.61 ± 66.05	≤ 0.001
Urinary creatinine/kg weight (mg/dL)/kg	26.50 ± 0.49	24.48 ± 0.87	25.51 ± 0.92	29.51 ± 0.63	≤ 0.001
Urinary citrate (mg/dL)	350.94 ± 9.69	394.30 ± 18.43	358.42 ± 17.25	300.10 ± 12.74	≤ 0.001
Urinary oxalate (mg/dL)	45.99 ± 1.18	44.73 ± 2.12	48.72 ± 2.13	44.52 ± 1.88	0.26
Urinary uric acid (g/dL)	857.61 ± 17.09	789.06 ± 32.06	823.79 ± 28.21	959.98 ± 25.28	≤ 0.001
Urinary calcium (mg/dL)	329.02 ± 8.02	288.25 ± 12.74	325.11 ± 15.52	373.70 ± 11.74	≤ 0.001
Job status					0.22
Engineer/physician	12	2	5	5	
Clerk	57	20	19	18	
Student	4	2	0	2	
Teacher	4	2	0	2	
Self-employed	77	28	28	21	
Retired	47	14	19	14	

Categorical variables are presented as frequency (n), and continuous variables as mean ± S.E. One-way ANOVA was used for continuous variables and person’s chi-square test for categorical variables.

	Total	Dietary inflammatory index score			
	N = 264	Tertile 1 (n = 88)	Tertile 2 (n = 88)	Tertile 3 (n = 88)	p-value
Worker	60	20	14	26	
Unemployed	3	0	3	0	
Marital status					0.82
Married	241	81	81	79	
Single	23	7	7	9	
Education level					0.68
Illiterate	10	3	4	3	
≤Diploma	190	59	66	65	
University degree	64	26	18	20	

Categorical variables are presented as frequency (n), and continuous variables as mean ± S.E. One-way ANOVA was used for continuous variables and person’s chi-square test for categorical variables.

Table 2
Univariate and multivariate logistic regression models for the relation of DII score to urinary risk factors of kidney stone formation

		Dietary inflammatory index score		
		Model 1 (Crude model)	**Model 2**	**Model 3**
		Odds ratio (95% CI)	**Odds ratio (95% CI)**	**Odds ratio (95% CI)**
Hypercreatininuria	T1	1	1	1
	T2	1.62 (0.88–3.01)	0.92 (0.45–1.89)	0.85 (0.41–1.78)
	T3	7.60 (3.28–17.61)	3.10 (1.23–7.81)	2.80 (1.10–7.12)
	P value for trend	≤ 0.001	0.02	0.04
Hypocitraturia	T1	1	1	1
	T2	1.60 (0.81–3.17)	1.53 (0.75–3.11)	1.69 (0.82–3.49)
	T3	6.04 (2.35–15.55)	5.64 (2.10-15.15)	5.84 (2.14–15.91)
	P value for trend	≤ 0.001	0.001	≤ 0.001
Hyperoxaluria	T1	1	1	1
	T2	1.34 (0.72–2.48)	1.47 (0.77–2.79)	1.63 (0.84–3.16)
	T3	0.86 (0.47–1.58)	0.99 (0.52–1.90)	1.12 (0.57–2.19)
	P value for trend	0.64	0.95	0.78
Hyperuricosuria	T1	1	1	1
	T2	1.69 (0.92–3.12)	1.08 (0.55–2.13)	1.20 (0.59–2.42)
	T3	4.40 (2.16–8.94)	2.14 (0.98–4.67)	2.22 (1.001–4.95)
	P value for trend	≤ 0.001	0.06	0.05
Hypercalciuria	T1	1	1	1
	T2	1.34 (0.72–2.51)	1.13 (0.59–2.18)	1.02 (0.52-2.00)

Model 2: adjusted for energy intake; Model 3: additionally adjusted for age, BMI, and physical activity.

		Dietary inflammatory index score		
		Model 1 (Crude model)	Model 2	Model 3
		Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)
	T3	10.45 (3.84–28.39)	8.11 (2.88–22.83)	7.44 (2.62–21.14)
	P value for trend	≤ 0.001	≤ 0.001	≤ 0.001

Model 2: adjusted for energy intake; Model 3: additionally adjusted for age, BMI, and physical activity.

DII score and urinary lithogenic factors

In the crude model, it was found that higher adherence to the DII was significantly related to the increased odds of hypercreatininuria (OR = 7.60, 95%CI: 3.28–17.61, P_{trend} ≤0.001), hypercalciuria (OR = 10.45, 95%CI: 3.84–28.39, P_{trend} ≤0.001), hyperuricosuria (OR = 4.40, 95%CI: 2.16–8.94, P_{trend} ≤0.001), and hypocitraturia (OR = 6.04, 95%CI: 2.35–15.55, P_{trend} ≤0.001). After multivariate adjustment for energy intake, age, physical activity and BMI, high DII scores were associated with elevated odds of having hypercreatininuria (OR = 2.80, 95%CI: 1.10–7.12, P_{trend}=0.04), hypercalciuria (OR = 7.44, 95%CI: 2.62–21.14, P_{trend} ≤0.001), hyperuricosuria (OR = 2.22, 95%CI: 1.001–4.95, P_{trend}= 0.05), and hypocitraturia (OR = 5.84, 95%CI: 2.14–15.91, P_{trend} ≤0.001). No association was identified between DII and hyperoxaluria.

Discussion

We revealed that, in stone former men, a diet with a high DII is significantly related to the increased odds of having hypercreatininuria, hypercalciuria, hyperuricosuria, and hypocitraturia, but not to hyperoxaluria.

It has been confirmed that kidney stone formers could be susceptible to recurrence in stones formation because of unhealthy dietary patterns [32]. We previously [30] found that adherence to an unhealthy dietary pattern, which was high in high fat diaries, red meats, sweets-desserts, junk foods, coke-fizzy drinks, and fast foods, is significantly associated with hypercalciuria and hypocitraturia, but not with hyperoxaluria. Nevertheless, inconsistent with our finding, a study did not report any significant difference in creatinine across tertiles of DII in subjects with chronic kidney disease [33]. A randomized controlled trial study by Noori et al. [34] on recurrent stone formers showed that a DASH diet, which in contrast to a diet with a high DII, is featured by a high intake of whole grains, fruits, low-fat dairy products and vegetables, and a low intake of total fat, cholesterol, saturated fat, meat, and refined grains, is significantly associated with a decrease in calcium oxalate supersaturation and an increase in citrate

excretion. Moreover, another study reported that greater adherence to the Mediterranean dietary pattern (characterized by high consumption of fruits and vegetables, fish, olive oil, nuts, and legumes; low consumption of saturated fats, meat, and sugars; and moderate consumption of wine, is related to the reduced risk for incident kidney stones [35]. The relationship between systemic inflammation and nephrolithiasis has been identified previously [13]. Since both DASH and Mediterranean diets attenuate inflammation [16 36], the protective effects of these dietary patterns on kidney stones formation may be mediated, at least partly, by reducing systemic inflammation. A cross-sectional conducted on diabetic patients also reported that higher intake of “vegetable and fish” dietary pattern is related to a lower creatinine rates [37]. Vegetables and fish, as components of DII, are identified to have anti-inflammatory effects [38 39]. The DII is a tool to assess the overall impact of a diet on inflammatory potential [29], and is associated with markers of systemic inflammation including such as IL-6 [24], and CRP [26] [..]; IL-6 and CRP are two of the inflammatory biomarkers considered in the calculation of DII [29]. It has been revealed that the DII score is inversely related to the Dietary Approaches to Stop Hypertension Score (DASH) ($r = -0.52$, $p < 0.01$), Mediterranean Diet Score ($r = -0.45$, $p < 0.01$), and Healthy Eating Index-2010 ($r = -0.65$, $p < 0.01$) [40 41]. Taken together, these findings support that a likely mechanism for the relation of DII scores to hypercreatininuria, hypercalciuria, hyperuricosuria, and hypocitraturia could be explained by the higher systemic inflammation level among people following a pro-inflammatory diet.

Conclusion

In conclusion, this study found that a diet with high inflammatory property might be unfavorably associated with urinary risk factors of kidney stone formation in men with a history of nephrolithiasis. Dietary recommendation for increasing the intake of foods with a lower inflammatory effect or foods with a higher anti-inflammatory potential could be part of the preventive approaches for the prevention of kidney stones by affecting urinary risk factors. Additional studies, particularly with prospective cohort design, are necessary to confirm these findings.

Limitation

This study is the first investigation on the association of DII with the urinary risk factors of kidney stone formation. Several limitations of this study should be considered when interpretation the findings. First, FFQ measured long-term food intake of participants, whereas 24-hour urinary concentrations of the urinary factors possibly are affected by short-term intake. Second, since the participants of the current study were limited to men, our findings may not be generalizable to women; therefore, it is essential to conduct such a study on women too. Third, causation cannot be inferred the cross-sectional design of the present investigation. Finally, the calculation of DII by FFQ has a potential recall bias for the evaluation of dietary intake. Though, the validity and reliability of the questionnaire were established previously.

Abbreviations

dietary inflammatory index (DII)

polyunsaturated fatty acids (PUFAs)

C- reactive protein (CRP)

food frequency questionnaire (FFQ)

International Physical Activity Questionnaires (IPAQ)

Analysis of variance (ANOVA)

Odds ratio (OR)

confidence interval (CI)

body mass index (BMI)

Declarations

Ethics approval and consent to participate: Ethics approval for the study protocol was granted by The Human Ethics Committee of Tehran University of Medical Sciences (Grant ID: IR.TUMS.VCR.REC1395.1046). All participants signed written informed consent forms.

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Author Contribution*:* "SMKA, and SSM designed the research and collected the samples; NSM and SHA wrote the paper; HY and MSY analyzed data;; KhM conducted research and had primary responsibility for final content. All authors read and approved the final manuscript."

Consent for publication: This is formally to submit the article entitled “The association of dietary inflammatory index with urinary risk factors of kidney stones formation in men with nephrolithiasis

” prepared by the Tehran University of Medical Sciences for review and, hopefully, publication in your prestigious journal. The authors would like to advise that all authors listed have contributed to the work. All authors have agreed to submit the manuscript to *BMC Research Notes*. No part of the work has been published before. There is no conflict of interest in this paper.

Not applicable

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