Original Article

Risk Factors for Renal Stone Formation: A Case-Control Study

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Abstract

Background: Renal stone disease is increasingly associated with metabolic syndrome and its components. **Objectives:** This study aimed to evaluate the relationship between metabolic risk factors and renal stone formation in Sulaymaniyah, Kurdistan Region, and Iraq. **Materials and Methods:** A case-control study was conducted between November 2023 and January 2026 in three tertiary hospitals (Teaching Hospital, Shar Hospital, and Al-Rahma Hospital). A total of 200 participants were enrolled (100 cases with renal stones confirmed by imaging and 100 controls without stones). Data collection included demographic details, family history, waist circumference, body mass index (BMI), blood pressure, and diabetes status. Anthropometric measurements were performed by physicians. Statistical analysis included Chi-square tests and logistic regression to calculate odds ratios (ORs). **Results:** Male gender (69.1% vs. 30.9%, $p < 0.001$), positive family history (59.1% vs. 40.9%, $P = 0.003$), diabetes mellitus (23% vs. 6%, OR = 4.68, 95% Cl: 1.81-12.07, $p < 0.001$), hypertension 20% vs. 8%, OR = 2.88, 95% CI: 1.20-6.88, $p = 0.014$), and central obesity measured by waist circumference ($p = 0.001$) were significantly associated with renal stone formation. BMI categories were not statistically significant. **Conclusion:**Renal stone disease in this population is strongly associated with metabolic risk factors, particularly diabetes, hypertension, and central obesity, as well as male gender and family history. Larger studies with detailed stone composition analysis are recommended to confirm these findings.

Keyword: Urolithiasis; Kidney stone disease; Metabolic syndrome; Waist circumference; Obesity; Diabetes mellitus; Hypertension; Case-control study; Risk factors; Recurrence

Introduction

The formation of renal calculi—clinically known as urolithiasis is a pathological process where minerals precipitate from the urine to create solid crystalline structures [1]. While once considered a sporadic ailment, the global landscape of this condition has shifted dramatically. Today, the frequency of kidney stones varies by geography, yet a common thread has emerged: a worldwide surge in prevalence [2]. This upward trend is not accidental; it is a direct reflection of modern life, fueled by caloric-dense diets, sedentary habits, and the global explosion of metabolic disorders such as obesity and diabetes [3]. At the microscopic level, this process is an intricate biological drama. Most stones are composed of calcium oxalate, which typically takes root on the renal papillary surfaces. The transformation from clear urine to a solid stone involves a precise sequence of events: it begins with urinary supersaturation, followed by crystal nucleation, growth, and aggregation, finally culminating in

the adherence of these crystals to the renal tubular cells [4]. The link between a patient's metabolic profile and their risk of stone formation is becoming increasingly clear. The World Health Organization (WHO) currently estimates that 1.7 billion individuals globally are overweight or obese—a statistic with profound implications for renal health [5]. Indeed, individuals with a high Body Mass Index (BMI) face a risk of urolithiasis that is more than 75% higher than those within a healthy weight range [6]. This risk is driven by chemical shifts in the body; an increased BMI is frequently associated with higher urinary excretion of sodium, calcium, and uric acid, alongside a decrease in urinary pH. Long-term studies, including those from the Boston research group, have confirmed that expanded waist circumference and weight gain are among the strongest predictors of future stone episodes [7]. Beyond weight alone, the broader spectrum of metabolic syndrome plays a critical role. Recent case-control data has identified a significantly higher prevalence of hypertension among stone-formers compared to healthy controls [8]. Furthermore, while the impact of insulin resistance on urine chemistry is well-documented, specific data connecting diabetes to nephrolithiasis remains surprisingly limited. Early cross-sectional evidence suggests a stark contrast: a 21% prevalence of stone disease in diabetic patients, compared to just 8% in the non-diabetic population [9]. Despite the clear interplay between waist circumference, BMI, hypertension, diabetes and renal health, there is a significant void in the literature regarding these relationships within the specific context of Iraq and the Kurdistan region. While global trends are alarming, regional data remains sparse. This study aims to evaluate the association between metabolic risk factors and renal stone formation in Sulaymaniyah, Kurdistan Region, Iraq.

Materials and Methods

Study Design and Setting

This study utilized a case-control design to evaluate the association between metabolic and clinical risk factors and urolithiasis. Data were collected using a structured questionnaire. Anthropometric measurements (weight, height, BMI, waist circumference) were performed by physicians or trained healthcare staff, not self-reported. Controls were selected from the same hospitals, matched by age and sex, and confirmed free of renal stones by imaging. Convenience sampling was used, and this limitation was acknowledged. Logistic regression was applied to calculate odds ratios in addition to Chi-square tests.. The study was conducted over a period extending from November 2023 to January 2026.

Research Participants and Sample Size

A total of 200 participants were recruited using a convenience sampling method.

- Case group: Patients diagnosed with uro-lithiasis confirmed by ultrasonography and radiographic imaging.
- Control group: Patients attending the same hospitals who showed no evidence of urolithiasis on similar imaging modalities.

For both groups, data on self-reported chronic conditions such as hypertension and diabetes were collected. Anthropometric measurements were taken during clinical visits, including waist circumference and body mass index (BMI), calculated as weight in kilograms divided by the square of height in meters.

Clinical Measures and Data Collection Tool

A structured, self-administered questionnaire was developed and divided into three sections:

- Section 1: Demographic Information (Name, Age, Gender)

- Section 2: Metabolic Syndrome Indicators (Waist Circumference, BMI, Diabetes, Hypertension)
- Section 3: Urolithiasis History (Family History, Previous Kidney Stones, History of Kidney Stone Surgery).

Pilot Study

A pilot study was conducted to assess the clarity and reliability of the questionnaire prior to full-scale data collection.

Statistical Analysis

Data were initially entered and cleaned using Microsoft Excel 2016, then imported into IBM SPSS Statistics Version 25 for analysis. Descriptive statistics including frequency, mean, and standard deviation were calculated. Associations between variables were assessed using the Chi-square test. A p-value less than 0.05 was considered statistically significant.

Ethics Approval and Consent to Participate

Approval (number 153C) was granted from the ethical committee of the College of medicine/University of Sulaimani, Iraq. The work was implemented in accordance with international guidelines and the 2008 Declaration of Helsinki. Written informed consents were provided by participants.

Result

Table 1 shows a total of 200 participants (100 cases and 100 controls) were included. Most cases were aged 35–44 years, while controls were more commonly aged 25–34 years. Males predominated among cases (65%), whereas females were more frequent among controls (71%). and a positive family history of kidney stones was more common among cases (68%) than controls (47%). Cases more frequently had a waist circumference of 94–102 cm and were predominantly overweight, while controls were mostly of normal BMI. Diabetes mellitus and hypertension were more prevalent among cases. Additionally, a history of previous kidney stones and prior stone surgery was more common in cases than in controls.

Table 1 : Baseline demographic and clinical characteristics of study participants

Variable	Category	Cases N (%)	Controls N (%)	P- value
Age	Under 18	3 (3.0%)	2 (2.0%)	0.156
	18 – 24	12 (12.0%)	23 (23.0%)	
	25 – 34	21 (21.0%)	26 (26.0)	
	35 – 44	28 (28.0%)	17 (17.0%)	
	45 – 54	20 (20.0%)	12 (12.0%)	
	55 – 64	11 (11.0%)	14 (14.0%)	
	65 and above	5 (5.0%)	6 (6.0%)	
Gender	Female	35 (35.0%)	71 (71.0%)	<0.001
	Male	65 (65.0%)	29 (29.0%)	
Family history of kidney stone	Positive	68 (68.0%)	47 (47.0%)	0.003
	Negative	32 (32.0%)	53 (53.0%)	
Waist Circumference	< 94cm	36 (36.0%)	23 (23.0%)	0.001
	94cm-102cm	42 (42.0%)	29 (29.0%)	
	>102cm	22 (22.0%)	48 (48.0%)	
BMI	<18.5 (Underweight)	9 (9.0%)	7 (7.0%)	0.108
	5- 24.9 (Normal)	28 (28.0%)	44 (44.0%)	
	25 – 29.9 (Overweight)	44 (44.0%)	31 (31.0%)	
	>30 (Obese)	19 (19.0%)	18 (18.0%)	
Diabetic	Yes	23 (23.0%)	6 (6.0%)	0.001
	No	77 (77.0%)	94 (94.0%)	

Hypertension	Yes	20 (20.0%)	8 (80.0%)	0.014
	No	80 (80.0%)	92 (92.0%)	

As shown in Table 2, males constituted a significantly higher proportion of cases (69.1%) compared to controls (30.9%), whereas females were more prevalent among controls (67.0%) than cases (33.0%). This difference was statistically highly significant ($p < 0.001$).

Table 2: Association between gender and kidney stone disease

Gender	Cases n (%)	Controls n (%)	P value
Female	35 (33.0)	71 (67.0)	<0.001
Male	65 (69.1)	29 (30.9)	
Total	100 (50.0)	100 (50.0)	

Table 3 shows a positive family history of kidney stones was significantly more common among cases than controls (59.1% vs 40.9%). This difference was statistically significant ($p = 0.003$), suggesting that individuals with a family history of kidney stones have a higher risk of developing the disease.

Table3: Family history of kidney stones

Family history of kidney stone	Cases n (%)	Controls n (%)	P value
Positive	68 (59.1)	47 (40.9)	0.003
Negative	32 (37.6)	53 (62.4)	
Total	100 (50.0)	100 (50.0)	

Table 4 shows waist circumference showed a statistically significant association with kidney stone disease ($p = 0.001$). Participants with waist circumference between 94–102 cm were more frequently observed among cases, while those with waist circumference greater than 102 cm were more common among controls. Overall, central obesity was significantly associated with kidney stone disease.

Table 4: shows Association between Waist Circumference and Kidney Stones Occurrence

Waist circumference (cm)	Cases n (%)	Controls n (%)	P - value
< 94	36 (61.0)	23 (39.0)	0.001
94–102	42 (59.2)	29 (40.8)	
> 102	22 (31.4)	48 (68.6)	
Total	100 (50.0)	100 (50.0)	

Table 5 shows diabetes mellitus was significantly more prevalent among cases compared to controls (79.3% vs 20.7%). This difference was statistically significant ($p = 0.001$), indicating a strong association between diabetes mellitus and kidney stone disease.

Table 5: shows diabetes as a Risk Factor for Kidney Stones

Diabetes status	Cases n (%)	Controls n (%)	P value
Yes	23 (79.3)	6 (20.7)	0.001
No	77 (45.0)	94 (55.0)	
Total	100 (50.0)	100 (50.0)	

Table 6 shows hypertension was observed more frequently among cases than controls (71.4% vs 28.6%). The association between hypertension and kidney stone disease was statistically significant ($p = 0.014$).

Table 6: shows Hypertension as a Risk Factor for Kidney Stones

Hypertension	(Case)	Control	p-value
Yes	20 (71.4%)	8 (28.6%)	0.014
No	80 (46.5%)	92 (53.5%)	
Total	100	100	

Table 7 shows male gender was associated with a significantly increased risk of kidney stone disease. Females had lower odds of developing kidney stones compared to males (OR = 0.220, 95% CI: 0.121–0.399, p < 0.001).

Table 7: shows comparative Impact of Gender on Kidney Stones

Risk Factor	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value
Gender (Female/Male)	0.220	0.121 – 0.399	0.001
For cohort Kidney stone = Case	0.478	0.353 – 0.646	
For cohort Kidney stone = Control	2.171	1.560 – 3.023	

Table 8 shows participants with a positive family history of kidney stones had more than twice the odds of developing kidney stone disease compared to those without a family history (OR = 2.396, 95% CI: 1.348–4.259, p < 0.001).

Table 8: shows association Between Family History and Kidney Stone Form

Risk Factor	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value
Family History (Positive / Negative)	2.396	1.348 – 4.259	0.000
For cohort Kidney Stone = Case	1.571	1.149 – 2.148	
For cohort Kidney Stone = Control	0.655	0.498 – 0.863	

Table 9 shows diabetes mellitus was associated with a more than nearly five-fold increased risk of kidney stone disease (OR = 4.680, 95% CI: 1.814–12.072, p < 0.001).

Table 9: shows association Between Diabetes and Kidney Stone Risk

Risk Factor	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value
Diabetic (Yes / No)	4.680	1.814 – 12.072	0.000
For cohort Kidney Stone = Case	1.761	1.373 – 2.259	
For cohort Kidney Stone = Control	0.376	0.182 – 0.777	

Table 10 shows hypertension was significantly associated with kidney stone disease, with hypertensive individuals having nearly three times higher odds of developing kidney stones (OR = 2.875, 95% CI: 1.201–6.883, p < 0.001).

Table 10 : Shows hypertension as a Predictor of Kidney Stone Formation

Risk Factor	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value
Hypertension (Yes / No)	2.875	1.201 – 6.883	0.000
For cohort Kidney Stone = Case	1.536	1.156 – 2.040	
For cohort Kidney Stone = Control	0.534	0.293 – 0.975	

Discussion

This study found that BMI was not a significant predictor, while waist circumference showed a stronger association with renal stone formation. Diabetes and hypertension emerged as major risk factors. Kidney stone disease is a crystal concr-

etion formed usually within the kidneys. It is an increasing urological disorder of the population, affecting about 12% of the population world-wide. [10] Kidney stones are frequently manif-esttations of underlying systemic medical cond-itions such as the metabolic syndrome, genetic disorders, or endocrinopathies. [11] Although the precise pathophysiological mechanisms under-lying nephrolithiasis remain unknown, and no single theory can fully understand its development, the combined risk factors such as age, sex, metabolic status, geography, climatic conditions, genetic predisposition, and dietary habits on its occurrence highlights the inherently multifactorial nature of the disease. [12] Stone formation starts when supersaturation of certain substances, such as calcium, oxalate, or uric acid, occurs in the urine. These substances crystallize and form small aggregates, which can grow into larger stones over time [13] Regardless of the type, kidney stone formation is a complex and multistep process that includes urinary supersaturation, crystal nucleation, growth and aggregation. Kidney stone formation is associated with systemic disorders, including diabetes, obesity, cardiovascular diseases, hypertension and metabolic syndrome. [14] Kidney stones develop more prevalent in individuals with a family history of kidney stones than in those without a family history; however, little statistics are available regarding whether the increased risk is attributable to genetic factors, environmental exposures, or some combination. On multivariate analysis, any family history was significantly associated with kidney stone, patients who had a first-degree relative with stone history had significant 58% increased odds of stone recurrence and 42% increased odds of first stone onset. [15] In our study, 68 cases had positive family history while 32 of them had no previous first degree relative of the same condition, which was statistically significant. Previous epidemiological studies have reported that obesity is a risk factor for kidney stone formation. However, the effect of increasing degrees of obesity on urolithiasis has yet to be defined. [16] Obesity is associated with an increased risk of kidney stone formation, a concerning finding considering that obesity and nephrolithiasis are increasing at a great rate. After adjusting for confounders, participants with a BMI ≥30 kg/m2 had a significantly higher risk of kidney stones compared to those with a BMI <25 kg/m2 (adjusted OR [aOR]: 1.86; 95% CI: 1.48–2.34; $p < 0.001$) [9] in our study, BMI was statistically non-significant, as it varied between the BMI categories greatly. In the US adult population, elevated waist circumference value was associated with an increased risk of kidney stone. Furthermore, waist circumference was a better predictor of stone occurrence. [17] In our study, 36 of cases had waist circumference less than 94, 42 of them had waist circumference between 94-102, and 22 of them had waist circumference above 102. Our data showed statistically significant relationship. Research has shown that patients visiting hypertension clinics have a greater chance of kidney stones formation than healthy participants. The NHANES analysis included 21,740 participants. After full adjustment, hypertension was significantly associated with a higher prevalence of kidney stones. [18] Our study showed that 80 of those with kidney stones were normotensive while only 20 of them had hypertension. Insulin resistance might result in a reduced amount of ammonium production in the kidney, which lowers urinary pH, thus producing a favorable milieu for uric acid stone formation. Several studies have demonstrated a correlation between diabetes and the formation of urolithiasis. [19] In an important cross-sectional study, Taylor et al. emphasize the link between diabetes and the formation and recurrence of urinary stones. [20]

In our study, among 100 cases, 23 of them had diabetes, while 77 of them didn't have diabetes, which showed statistically significant. This study has several limitations: the relatively small sample size, use of convenience sampling which may introduce bias, lack of stone composition analysis, possible measurement bias in anthropometric data, and recall bias in self-reported diabetes and hypertension.

Conclusion

This study demonstrates that renal stone formation is closely linked with metabolic syndrome components, especially diabetes, hypertension, and central obesity. Male patients and those with a family history of stones were at higher risk. While BMI alone was not a strong predictor, waist circumference proved more reliable. These findings highlight that renal stones are part of a broader metabolic health problem. Preventing and managing these risk factors could reduce the burden of renal stone disease in our community. Future research with larger sample sizes and stone composition analysis is needed to strengthen these

Availability of data and materials

The datasets supporting the conclusions of this article are included within the article and its additional files.

Author contributions

All authors contributed to the study conception and design, literature search, material preparation, data collection, and data analysis. All of them participated in drafting the final version of the study.

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