Original Article

Kidney stone characteristics in diabetics versus nondiabetics at a tertiary care center in Saudi Arabia

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Abstract

Background: Kidney stones can significantly impact individuals, but existing literature often overlooks the comprehensive effects by not considering the various factors such as stone size, presence of obstruction, and treatment methods, among those with and without diabetes. This study seeks to explore the relationship between diabetes and kidney stone formation, addressing these gaps in research.

Methodology: This cross-sectional study assesses the diverse impacts of kidney stones on adults diagnosed with type 2 diabetes mellitus and nondiabetic adults from 2019 to 2022 in Jeddah, Saudi Arabia. Institutional review board approval was secured for this research. Data collection occurred from December 1, 2022, to March 1, 2023, and the analysis was performed using SPSS software.

Results: The study included 254 adults diagnosed with kidney stones, 127 with type 2 diabetes, and 127 nondiabetics. Our study showed that the individuals with diabetes were more likely to have larger kidney stones than those without diabetes (13.12 mm vs. 10.53 mm, $P = 0.03$). Moreover, individuals with hypertension and dyslipidemia also had significantly larger stones. However, no significant difference was found between the two groups regarding the presence of obstruction and the treatment modality.

Conclusion: This study revealed that in Saudi Arabia, individuals with diabetes who also suffer from kidney stones tend to develop larger stones. In addition, these individuals frequently exhibit other comorbid conditions, including hypertension, dyslipidemia, obesity, and renal disease. The significance of these findings may inform future strategies for both primary and secondary prevention of kidney stones in diabetic patients.

Keywords: Kidney stones, lithotripsy, metabolic syndrome, type 2 diabetes mellitus, ureteric obstruction

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INTRODUCTION

The incidence of kidney stone disease is increasing globally. According to the National Health and Nutrition Examination Survey, a program associated with the Centers for Disease Control and Prevention, nephrolithiasis had a prevalence of 8.8% in the United States between 2007 and 2010, increasing to 10.1% in 2013–2014.[1,2] Nephrolithiasis has been associated with specific conditions, such as chronic

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kidney disease, end-stage renal disease, cardiovascular diseases, diabetes, and hypertension.[3,4] The disease affects all age groups, with a male-to-female ratio of 2:1.[5] The risk of developing kidney stones is high in Saudi Arabia compared to other countries, including Canada, the United States, and European countries,[6] which may be partly attributable to higher temperatures and dry weather.[7,8]

Many factors have been associated with an increased risk of developing renal stones, such as hypercalciuria, hyperoxaluria, hyperuricosuria, and hypocitraturia. Pathologically, kidney stones form from the crystallization of solutes in the urine. Etiologies associated with this incidence include systemic acidosis, medications, and urinary tract infections.[9] The recurrence rate of kidney stones in industrialized countries may be as high as 50%,[10] which may increase the risk of renal stone complications such as abscess formation, ureteral scarring, and stenosis, and renal function loss due to long-standing obstruction.[11]

Diabetes mellitus (DM) is one of the most prevalent diseases worldwide and is known to cause a wide range of complications, including cardiovascular diseases, retinopathy, peripheral neuropathy, and nephropathy leading to renal failure.[12] The global prevalence of diabetes in 2019 was estimated at 9.3%. In addition, Saudi Arabia has the seventh highest rate of diabetes in the world according to the World Health Organization, which makes it a pressing public health problem.[13,14] Previous studies have shown an increased risk of kidney stones in diabetic patients.[15] Insulin resistance, the primary pathological feature in type 2 DM, has been associated with a decrease in urine pH that favors the formation of kidney stones, especially uric acid stones.[9,15] Other studies have also found that poorer DM control was associated with a heightened risk of kidney stones.[16]

Our study aims to assess the severity of kidney stones among diabetic patients in our center and examine differences between stone formers with and without diabetes. Furthermore, we intend to assess whether poor DM control is associated with worse outcomes in those who develop kidney stones. To our knowledge, this is the first study in Saudi Arabia assessing the risk of kidney stones in people with diabetes.

METHODOLOGY

This cross-sectional study was conducted at a single center in Jeddah, Western region, Saudi Arabia. The study included all patients diagnosed with kidney stones through imaging who were type 2 diabetic, aged 18 years and older, and received follow-up between 2019 and 2022. Nondiabetic controls were also included. Patients with missing data such as glucose, hemoglobin A1C (HbA1c), and abdominal ultrasonography were excluded. Patients diagnosed with gout, cancer, malabsorption, endocrine disorders, congenital urinary system abnormalities, and renal disease with an estimated glomerular filtration rate <60 were also excluded.

The primary objective was to assess whether patients with diabetes were at higher risk than nondiabetics of developing complicated renal stones requiring surgical intervention. The following were considered poor outcomes associated with stones: large stone size, the need for lithotripsy or surgery, and the presence of obstruction. The secondary objectives of the study included determining the difference in stone characteristics between diabetics and nondiabetics, the difference in outcomes between well-controlled and poorly controlled diabetes, and the difference in outcomes between insulin users and noninsulin users.

The sample size was determined based on the estimated annual cases of DM in our endocrinology clinics, which is approximately 700 cases. Using the Raosoft sample size calculator, with a margin of error of 5%, confidence level of 95%, and response distribution of 50%, the minimum sample size was determined to be 249 patients. Relevant data, including demographic information, clinical characteristics, comorbidities, laboratory test results, and kidney stone characteristics, were extracted from electronic medical records. Descriptive statistics were used for univariate analysis and categorical variables were analyzed using Chi-square or Fisher's exact tests, while continuous variables were analyzed using *t*-tests. Normality assumptions were examined, and log transformation was applied for skewed numeric variables.

Statistical analyses were the data performed using the Statistical Package for the Social Sciences (SPSS) software version 20.0, SPSS Inc, Chicago, IL, USA. The study was conducted in accordance with relevant ethical guidelines and obtained the necessary ethical and Institutional Review Board (IRB) approval number IRB/1208/22 from King Abdullah International Medical Research Center. The Helsinki Declaration has also been followed in this research. Patient privacy and confidentiality were maintained by de-identifying and using anonymized patient identifiers.

RESULTS

The study included a total cohort of 254 patients diagnosed with kidney stones: half were type 2 diabetics (DM group)

Table 1: Baseline characteristics of nephrolithiasis patients with and without diabetes (univariate analysis)

	Diabetics before the renal stone		P^b
	Yes, *n* (%)[a]	No, *n* (%)[a]	
Total	127 (50)	127 (50)	
Age (years)			
Mean/SD	56/10.54	43/14.73	0.002
Gender			
Male	98 (77.17)	102 (80.31)	0.53
Female	29 (22.83)	25 (19.69)	
BMI (kg/m^2)			
Mean/SD	31.03/5.57	28.63/5.95	0.45
Hypertension			
Yes	88 (69.29)	17 (13.39)	<0.0001
No	39 (30.71)	110 (86.61)	
Obesity			
Yes	72 (56.69)	35 (27.56)	<0.0001
No	55 (43.31)	92 (56.69)	
Presence of obstruction			
Yes	44 (35.77)	47 (37.6)	0.76
No	79 (64.23)	78 (62.4)	
Renal disease			
Yes	20 (15.75)	9 (7.09)	0.03
No	107 (84.25)	118 (92.01)	
DLP			
Yes	53 (41.73)	7 (5.51)	<0.0001
No	74 (58.27)	120 (94.49)	
Patient on any DLP medication**			
Yes	79 (63.2)	6 (4.72)	<0.0001
No	46 (36.8)	121 (95.28)	
Type of kidney stone treatment			
Conservative	70 (55.12)	76 (59.84)	0.38
Lithotripsy	32 (25.2)	21 (16.54)	
Surgery/lithotripsy	6 (4.72)	8 (6.3)	
Surgery	19 (14.96)	22 (17.32)	
Size of kidney stone			
Mean/SD	13.12/16.51	10.53/13.49	0.03
Blood calcium levels (mmol/L)			
Mean/SD	2.3/0.12	2.3/0.1	0.17
Blood magnesium levels (mmol/L)			
Mean/SD	0.93/0.77	0.86/0.21	<0.0001
Creatinine (µmol/L)			
Mean/SD	97.21/43.33	82.77/23.5	<0.0001
Fasting plasma glucose (mmol/L)			
Mean/SD	8.61/3.61	5.41/1.32	<0.0001
HDL (mmol/L)			
Mean/SD	0.97/0.22	1.14/0.3	0.004
LDL (mmol/L)			
Mean/SD	2.39/1.05	3.04/1.14	0.57
Random blood glucose (mmol/L)			
Mean/SD	9.77/4.21	6.85/9.05	<0.0001
TSH (mIU/L)			
Mean/SD	4.94/27.39	2.1/1.91	<0.0001
Triglyceride (mmol/L)			
Mean/SD	1.92/1.53	1.6/1.17	0.01
Urine pH			
Mean/SD	5.22/0.51	5.41/1.3	0.51
PTH (pg/mL)			
Mean/SD	97.34/60.73	138.7/220.4	<0.0001
Hemoglobin A1C (%)			
Mean/SD	7.91/1.57	5.53/0.88	<0.0001

**Missing, [a]*n* (%) frequency and percentage, [b]Chi-square test, *t*-test, and Fisher's exact test when appropriate. PTH: Parathyroid hormone, DLP: Dyslipidemia, BMI: Body mass index, SD: Standard deviation, TSH: Thyroid-stimulating hormone, HDL: High-density lipoprotein, LDL: low-density lipoprotein

Table 2: Multivariate analysis for "presence of obstruction" with categorical variables

Presence of obstruction	No (*n*=160), *n* (%)	Yes (*n*=91), *n* (%)	*P*
Gender			
Male	121 (75.6)	78 (85.7)	0.058*
Female	39 (24.4)	13 (14.3)	
Hypertension			
No	100 (62.5)	50 (54.9)	0.241*
Yes	60 (37.5)	41 (45.1)	
DLP			
No	122 (76.3)	73 (80.2)	0.468*
Yes	38 (23.8)	18 (19.8)	
Obesity			
No	89 (55.6)	54 (59.3)	0.568*
Yes	71 (44.4)	37 (40.7)	
Insulin use?	*n*=80	*n*=44	
No	58 (72.5)	37 (84.1)	0.145*
Yes	22 (27.5)	7 (15.9)	
Type of kidney stone treatment			
Lithotripsy	32 (20.0)	21 (23.1)	0.225*
Conservative	98 (61.3)	46 (50.5)	
Surgery	30 (18.8)	24 (26.4)	

*Chi-squared test. DLP: Dyslipidemia

Table 3: Multivariate analysis for "presence of obstruction" with numerical variables

Presence of obstruction	*n*	Median	Mean rank	*Z*	*P*
Size of stone					
No	140	10.2	102.83	−2.762	0.006*
Yes	83	14.3	127.48		
Age					
No	160	49.7	125.45	−0.158	0.874*
Yes	91	50.1	126.96		
BMI					
No	158	29.8	125.58	−0.167	0.867*
Yes	91	29.9	123.99		
Hemoglobin A1C (%)					
No	121	7.1	87.60	−0.157	0.875*
Yes	54	7.1	88.90		
Urine pH					
No	49	5.2	40.79	−1.169	0.242*
Yes	36	5.4	46.01		

*Mann–Whitney test. BMI: Body mass index

and the other half were a control group. In the univariate analysis, diabetic patients were significantly older, with a mean age of 56 years, compared to the nondiabetic patients, who had a mean age of 40 years ($P = 0.002$). A large proportion of the cohort were male (78.74%). As shown in Table 1, more patients in the DM group were also obese, dyslipidemic, and hypertensive. In the DM group, 63.2% were taking lipid-lowering agents, compared to 4.72% in the control group ($P < 0.001$). Blood magnesium, creatinine, fasting plasma glucose, and HbA1c were significantly higher in the DM group.

The mean size of kidney stones among diabetic patients was larger (13.12 mm) than in nondiabetic patients (10.53 mm), $P = 0.03$ [Table 1]. Around a third of the patients in each group presented with an obstructive stone, with no significant difference between the groups. More patients in the DM group required lithotripsy than in the non-DM group (25.20% vs. 16.54%, $P = 0.38$).

When assessing the primary outcomes, we found that the presence of obstruction did not differ in relation to gender or preexisting comorbidities [Table 2]. The stone size was significantly higher in those presenting with obstruction (14.3 mm) than in those with nonobstructive stones (10.2 mm), $P = 0.006$, as shown in Table 3. There was no difference in stone size between insulin users and noninsulin users; however, patients with dyslipidemia had a significantly larger stone size (14 mm vs. 10.3 mm, $P = 0.027$). Moreover, patients requiring surgery or lithotripsy had a larger stone size than those whose stones were managed conservatively, as shown in Table 4.

Table 4: Multivariate analysis for "size of the stone" with categorical variables

	n	Median	Mean rank	*Z*	*P*
Gender					
Male	180	12.3	115.38	−0.392	0.695*
Female	48	9.7	111.19		
Hypertension					
No	138	10.3	106.14	−2.374	0.018*
Yes	90	14.0	127.32		
DLP					
No	174	10.3	109.14	−2.208	0.027*
Yes	54	16.7	131.79		
Obesity					
No	130	11.9	115.97	−0.387	0.699*
Yes	98	11.5	112.56		
Insulin use?					
No	84	13.1	54.52	−0.577	0.564*
Yes	26	13.1	58.65		
Type of kidney stone treatment	***n***	**Median**	**Mean rank**	**χ^2**	***P***
Lithotripsy	51	12.7	139.68	30.131	<0.001†
Conservative	127	10.5	93.17		
Surgery	50	14.0	143.00		

*Mann–Whitney test, †Kruskal–Wallis test. DLP: Dyslipidemia

Tables 5 and 6 show that the treatment modality was not statistically different when assessing for the following categorical and numerical variables (except for the size of the kidney stone): hypertension, dyslipidemia, obesity, insulin use, HbA1c, and urine pH.

DISCUSSION

DM is becoming a concerning public health issue in developed and developing countries alike, especially in the older population. Diabetes is estimated to affect 537 million adults worldwide, with a global prevalence of 10.5% among adults aged 20–79. Type 2 diabetes represents approximately 98% of global diabetes diagnoses, although this proportion varies widely among countries.[17] This study aimed to assess the severity of kidney stones using multiple parameters to compare patients with diabetes to those without diabetes. These parameters include stone size, presence of obstruction, and treatment modality. Our findings suggest that patients who have diabetes are likely to have larger kidney stones than patients without diabetes. A separate study conducted in Pakistan reached the same conclusion, finding that kidney stones were larger in patients with diabetes than in individuals without diabetes.[18] Furthermore, while the size of renal stones was a significant finding when comparing patients with and without diabetes, no differences were identified in the presence of obstruction or the treatment modality. In addition, in the diabetic population, our results indicate that

Table 5: Multivariate analysis for "modality of treatment" with categorical variables

	Type of kidney stone treatment			*P*
	Lithotripsy (*n*=54), *n* (%)	Conservative (*n*=149), *n* (%)	Surgery (*n*=55), *n* (%)	
Presence of obstruction				
No	32 (60.4)	98 (68.1)	30 (55.6)	0.225*
Yes	21 (39.6)	46 (31.9)	24 (44.4)	
Gender				
Male	41 (75.9)	116 (77.9)	47 (85.5)	0.404*
Female	13 (24.1)	33 (22.1)	8 (14.5)	
Hypertension				
No	31 (57.4)	91 (61.1)	31 (56.4)	0.790*
Yes	23 (42.6)	58 (38.9)	24 (43.6)	
DLP				
No	36 (66.7)	111 (74.5)	50 (90.9)	0.008*
Yes	18 (33.3)	38 (25.5)	5 (9.1)	
Obesity				
No	26 (48.1)	89 (59.7)	33 (60.0)	0.305*
Yes	28 (51.9)	60 (40.3)	22 (40.0)	
Insulin use?	*n*=32	*n*=72	*n*=25	
No	24 (75.0)	51 (70.8)	22 (88.0)	0.231*
Yes	8 (25.0)	21 (29.2)	3 (12.0)	

*Chi-squared test, †Fisher's exact test. DLP: Dyslipidemia the use of insulin or the level of HbA1c had no significant impact on the presence of obstruction.

Diabetes has been linked to an increased risk of kidney stone formation; some studies have even identified it as a risk factor.[19] The cause is thought to be insulin resistance, which may manifest as a defect in ammonium production in the kidney. Insulin resistance can lead to higher levels of plasma-free fatty acids, which can enter the proximal tubule cells and interfere with the utilization of glutamine in the production of ammonium. The effect of insulin resistance on the kidney may directly affect ammoniagenesis, further contributing to the risk of kidney stone formation.[20]

Metabolic syndrome is diagnosed when an individual exhibits three out of five of the following characteristics: impaired glucose tolerance, hypertension, obesity, low serum levels of high-density lipoproteins (HDLs), and high serum levels of triglycerides. Metabolic syndrome is a significant global health issue as it is associated with an increased risk of cardiovascular diseases and type 2 diabetes. Moreover, there has been a worldwide increase in the occurrence of kidney stones, and some researchers believe there is an association between metabolic syndrome and kidney stones.[21] Our results indicate that patients with diabetes have a higher chance of exhibiting multiple comorbidities, including hypertension, dyslipidemia, obesity, and renal disease. Patients with diabetes are twice as likely to have hypertension as those without diabetes.[22] In our study, hypertension and high body mass index were more prevalent in patients who had diabetes compared to individuals without diabetes. Our research revealed that patients with diabetes had lower HDL levels than individuals without diabetes. Similar findings have emerged in multiple other studies conducted in various regions.[23,24] Our findings indicate a substantial correlation between hypertension and dyslipidemia and the presence of larger kidney stones.

Table 6: Multivariate analysis for "modality of treatment" with numerical variables

Type of kidney stone treatment	*n*	Median	Mean rank	χ^2	*P*
Size of stone					
Lithotripsy	51	12.7	139.68	30.131	<0.001*
Conservative	127	10.5	93.17		
Surgery	50	14.0	143.00		
Age					
Lithotripsy	54	50.4	132.57	3.642	0.162*
Conservative	149	48.6	122.73		
Surgery	55	53.0	144.83		
BMI					
Lithotripsy	54	29.7	134.91	0.789	0.674*
Conservative	147	30.0	128.46		
Surgery	55	29.3	122.31		
Hemoglobin A1C (%)					
Lithotripsy	37	7.4	98.82	1.268	0.531*
Conservative	110	7.1	87.83		
Surgery	34	7.2	92.75		
Urine pH					
Lithotripsy	15	5.3	37.83	1.197	0.550*
Conservative	49	5.3	43.86		
Surgery	21	5.4	44.69		

*Kruskal–Wallis test. BMI: Body mass index

Some studies have shown that poorly controlled diabetes, reflected by HbA1c above 6.5% and insulin use, is associated with a heightened risk of kidney stones.[16] According to our results, there was no significant correlation between the primary outcomes (size, presence of obstruction, or modality of treatment; and the level of HbA1c or the use of insulin). In contrast, statistical significance was found in the relationship between the modality of nephrolithiasis treatment and stone size. In concordance with our study, the American Urological Association/Endourological Society Guideline recommends that lithotripsy should constitute the primary treatment modality for upper urinary tract stones measuring <20 mm; however, larger stones are primarily managed through surgical intervention.[25]

Our study presents several strengths. It is, according to our literature review, the first in the Saudi Arabian region to explore the relationship between diabetes and renal stones. We rigorously selected participants, including only those with imaging-confirmed renal stones and excluding any self-reported cases. In addition, our analysis considered multiple indicators of high-burden disease, such as stone size, the presence of obstruction, and the treatment approach used. However, there are also notable limitations to our research. Being a single-center study, the findings may not fully represent the broader Saudi population. The cross-sectional design introduces inherent selection and referral biases, and also causality cannot be established. Furthermore, given the design of the study, it is difficult to observe trends or the progress of the condition over time, and it is challenging to control for confounding variables. Moreover, the limited availability of urine electrolyte data in our study subjects restricts the depth of our analysis. Another significant drawback is the absence of stone analysis data for most patients who underwent interventions, which impedes the precise identification of stone types.

In summary, our study provides additional evidence consistent with existing research that diabetics are at a higher risk of developing larger kidney stones. This research enhances our understanding of this correlation and supports the implementation of improved preventive strategies and screening protocols, ultimately aiming to enhance the quality of life for diabetics in Saudi Arabia.

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Conflicts of interest

There are no conflicts of interest.

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