Original Article

The effect of the body mass index on the types of urinary tract stones

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Abstract

Objectives: Urinary tract stones are a common public health problem worldwide. In addition, identifying the composition of stones is important for the further metabolic evaluation of patients. We conducted this study to further correlate the relationship between body mass index (BMI) and different compositions of urinary tract stones.

Materials and Methods: A retrospective study of 433 patients who underwent urinary tract stone analysis via Fourier-transform infrared spectroscopy at King Khalid University Hospital in Riyadh from May 2015 to June 2017 was performed. Their BMI at the time of stone analysis was recorded.

Results: A total of 433 stones were analyzed by the statistical data analysis software. The BMI was classified according to the WHO classification. We divided our patients into seven age groups. Most patients were between the age group of 35 and 44 years and were overweight. The incidence of calcium oxalate, carbonate apatite, and uric acid stones was higher in patients with a BMI above thirty than in patients with a lower BMI. However, cystine stones were more common in normal-weight patients.

Conclusions: In this study, we found that the incidence of certain types of stones, such as calcium oxalate, cystine, and uric acid stones, in Saudi Arabia can be predicted by BMI measurement.

Keywords: Body mass index, calcium oxalate stones, urinary tract stones, urolithiasis

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INTRODUCTION

Urinary tract stones are a common public health problem worldwide.[1] Calcium oxalate and calcium phosphate stones are the most common types, accounting for >80% of urinary tract stones. Other types of stones, including uric acid, cystine, and struvite stones, account for most of the remaining stones.[2] The prevalence and incidence of urolithiasis vary among different countries and races and between the sexes.[3] The lifetime incidence of urolithiasis in Middle Eastern and Western countries is 25% and 10%, respectively. However, the recurrence rates are high, reaching 50% worldwide.[4]

The pathophysiology of urolithiasis is complicated and incompletely understood; it is affected by many interacting

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factors, such as genetic, metabolic, and environmental factors.[5,6] Furthermore, the presence of risk factors such as obesity, diabetes, hypertension, and metabolic syndrome may promote the formation of stones in the urinary tract.[5] Recent studies have shown that patients with increased body mass index (BMI) tend to have a higher excretion of sodium, calcium, uric acid, and citrate and a lower urinary pH than nonobese patients.[7]

The aim of this study is to correlate BMI with specific types of urinary tract stones in Saudi Arabia and further explore this relationship. This aim was addressed by analyzing data from patients who underwent urinary tract stone analysis via Fourier-transform infrared spectroscopy (FTIR).

MATERIALS AND METHODS

A retrospective study including 433 patients who underwent urinary tract stone analysis via FTIR at King Khalid University Hospital (KKUH) in Riyadh from May 2015 to June 2017 was performed.

Our data were obtained from the special biochemistry laboratory at the KKUH after obtaining Institutional Review Board approval. Data privacy was maintained throughout the entire process.

Patient demographics (age, sex, and BMI), comorbidities (hypertension, diabetes mellitus, dyslipidemia and patient-specific comorbidities and stone types were included in our data.

RESULTS

Our data were analyzed using statistical data analysis software IBM SPSS Statistics for Windows, Version 25.0. (Armonk, NY: IBM Corp) to assess a sample of 433 patients with urolithiasis who underwent FTIR. Of the patients, 316 (73%) were male and 117 (27%) were female, for a male-to-female ratio of 2.7:1.

We classified the BMI of our patients according to the WHO classification into six groups (underweight, normal weight, overweight, Class I obesity, Class II obesity, and Class III obesity).[8] Furthermore, we divided the patients into seven groups according to age (0–14, 15–24, 25–34, 35–44, 45–54, 55–64, and 65+). Most patients were between the ages of 35 and 44 years, accounting for 99 (22.9%) of all patients. In addition, most patients were overweight, accounting for 137 (31.6%) of all patients [Table 1].

The majority of male patients were overweight, accounting for 111 (35.1%) of the 316 male patients. Female

Table 1: Age and different body mass index classifications

	Age							Total
	0-14	15-24	25-34	35-44	45-54	55-64	65+	
Underweight								
Count	16	2	3	1	0	2	0	24
Percentage within BMI	66.7	8.3	12.5	4.2	0.0	8.3	0.0	100.0
Percentage within age	69.6	9.5	3.4	1.0	0.0	2.6	0.0	5.5
Normal weight								
Count	7	9	26	14	10	8	7	81
Percentage within BMI	8.6	11.1	32.1	17.3	12.3	9.9	8.6	100.0
Percentage within age	30.4	42.9	29.9	14.1	11.9	10.5	16.3	18.7
Overweight								
Count	0	6	24	33	24	30	20	137
Percentage within BMI	0.0	4.4	17.5	24.1	17.5	21.9	14.6	100.0
Percentage within age	0.0	28.6	27.6	33.3	28.6	39.5	46.5	31.6
Class I obesity								
Count	0	2	19	26	30	22	9	108
Percentage within BMI	0.0	1.9	17.6	24.1	27.8	20.4	8.3	100.0
Percentage within age	0.0	9.5	21.8	26.3	35.7	28.9	20.9	24.9
Class II obesity								
Count	0	1	14	15	13	5	5	53
Percentage within BMI	0.0	1.9	26.4	28.3	24.5	9.4	9.4	100.0
Percentage within age	0.0	4.8	16.1	15.2	15.5	6.6	11.6	12.2
Class III obesity								
Count	0	1	1	10	7	9	2	30
Percentage within BMI	0.0	3.3	3.3	33.3	23.3	30.0	6.7	100.0
Percentage within age	0.0	4.8	1.1	10.1	8.3	11.8	4.7	6.9
Total								
Count	23	21	87	99	84	76	43	433
Percentage within BMI	5.3	4.8	20.1	22.9	19.4	17.6	9.9	100.0
Percentage within age	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

BMI: Body mass index

Table 2: Sex and different body mass index classifications

	Sex		Total
	Female	Male	
Underweight			
Count	10	14	24
Percentage within BMI	41.7	58.3	100.0
Percentage within sex	8.5	4.4	5.5
Normal weight			
Count	17	64	81
Percentage within BMI	21.0	79.0	100.0
Percentage within Sex	14.5	20.3	18.7
Overweight			
Count	26	111	137
Percentage within BMI	19.0	81.0	100.0
Percentage within sex	22.2	35.1	31.6
Class I obesity			
Count	30	78	108
Percentage within BMI	27.8	72.2	100.0
Percentage within sex	25.6	24.7	24.9
Class II obesity			
Count	19	34	53
Percentage within BMI	35.8	64.2	100.0
Percentage within sex	16.2	10.8	12.2
Class III obesity			
Count	15	15	30
Percentage within BMI	50.0	50.0	100.0
Percentage within sex	12.8	4.7	6.9
Total			
Count	117	316	433
Percentage within BMI	27.0	73.0	100.0
Percentage within sex	100.0	100.0	100.0

BMI: Body mass index

patients in our sample were mostly classified as Class I obesity, accounting for 30 (25.6%) of the 117 female patients [Table 2].

Our study included 24 underweight patients with stones; most of these stones were carbonate apatite (45.8%), calcium oxalate (33.3%), or ammonium (16.7%) stones. In addition, we had 81 normal-weight patients with stones, which were mostly calcium oxalate (50.6%), carbonate apatite (32.1%), and cystine (12.3%) stones. We had 137 overweight patients with stones; most of these stones were calcium oxalate (61.3%), carbonate apatite (27.7%), and uric acid (7.3%) stones. We had 108 patients classified as Class I obesity with stones; most of these stones were calcium oxalate (52.8%), carbonate apatite (32.4%), and uric acid stones (10.2). We had 53 patients classified as Class II obesity with stones; most of these stones were calcium oxalate (50.9%), carbonate apatite (37.7%), and uric acid (7.5%) stones. Finally, we had a total of 30 patients classified as Class III obesity with stones; most of these stones were carbonate apatite (46.7%), calcium oxalate (33.3%), and uric acid (10%) stones [Table 3].

Table 3: All types of stones in relation to body mass index, with the value of *P*

	BMI						Total
	Underweight	Normal weight	Overweight	Class I obesity	Class II obesity	Class III obesity	
Ammonium							
Count	4	1	3	3	0	1	12
Percentage within stone type	33.3	8.3	25.0	25.0	0.0	8.3	100.0
Percentage within BMI	16.7	1.2	2.2	2.8	0.0	3.3	2.8
Calcium oxalate							
Count	8	41	84	57	27	10	227
Percentage within stone type	3.5	18.1	37.0	25.1	11.9	4.4	100.0
Percentage within BMI	33.3	50.6	61.3	52.8	50.9	33.3	52.4
Carbonate apatite							
Count	11	26	38	35	20	14	144
Percentage within Stone Type	7.6	18.1	26.4	24.3	13.9	9.7	100.0
Percentage within BMI	45.8	32.1	27.7	32.4	37.7	46.7	33.3
Cystine							
Count	1	10	2	1	2	2	18
Percentage within stone type	5.6	55.6	11.1	5.6	11.1	11.1	100.0
Percentage within BMI	4.2	12.3	1.5	0.9	3.8	6.7	4.2
Monohydrogen phosphate							
Count	0	0	0	1	0	0	1
Percentage within stone type	0.0	0.0	0.0	100.0	0.0	0.0	100.0
Percentage within BMI	0.0	0.0	0.0	0.9	0.0	0.0	0.2
Uric acid							
Count	0	3	10	11	4	3	31
Percentage within stone type	0.0	9.7	32.3	35.5	12.9	9.7	100.0
Percentage within BMI	0.0	3.7	7.3	10.2	7.5	10.0	7.2
Total							
Count	24	81	137	108	53	30	433
Percentage within stone type	5.5	18.7	31.6	24.9	12.2	6.9	100.0
Percentage within BMI	100.0	100.0	100.0	100.0	100.0	100.0	100.0
P				0.000382			

BMI: Body mass index

We calculated the value of *P* for all stone types and for each type individually in relation to BMI. The value of *P* for the association between overall stone type and BMI was 0.000382. Furthermore, the value of *P* for the association with the BMI was 0.001 for ammonium stones [Table 4], 0.03 for calcium oxalate stones [Table 5], 0.253 for carbonate apatite stones [Table 6], 0.03 for cystine stones [Table 7], and 0.395 for uric acid stones [Table 8].

Calcium oxalate stones accounted for 227 (52.4%) of all stones in our sample. Eighty-four (37%) of these stones were found in overweight patients, while 57 (25.1%) were found in patients classified as Class I obesity. Carbonate apatite stones accounted for 144 (33.3%) of all stones in our sample. Thirty-eight (26.4%) of these stones were found in overweight patients, while 35 (24.3%) were found in patients classified as Class I obesity.

Table 4: Ammonium stones in relation to body mass index, with the value of *P*

BMI	Percentage	Stone type		Total
		Ammonium	Not ammonium	
BMI				
Underweight	Count	4	20	24
	Percentage within BMI	16.7	83.3	100.0
	Percentage within stone type	33.3	4.8	5.5
Normal weight	Count	1	80	81
	Percentage within BMI	1.2	98.8	100.0
	Percentage within stone type	8.3	19.0	18.7
Overweight	Count	3	134	137
	Percentage within BMI	2.2	97.8	100.0
	Percentage within stone type	25.0	31.8	31.6
Class I obesity	Count	3	105	108
	Percentage within BMI	2.8	97.2	100.0
	Percentage within stone type	25.0	24.9	24.9
Class II obesity	Count	0	53	53
	Percentage within BMI	0.0	100.0	100.0
	Percentage within stone type	0.0	12.6	12.2
Class III obesity	Count	1	29	30
	Percentage within BMI	3.3	96.7	100.0
	Percentage within stone type	8.3	6.9	6.9
Total	Count	12	421	433
	Percentage within BMI	2.8	97.2	100.0
	Percentage within stone type	100.0	100.0	100.0
P		0.001		

BMI: Body mass index

Table 5: Calcium oxalate stones in relation to body mass index, with the value of *P*

BMI	Percentage	Stone type		Total
		Calcium oxalate	Not calcium oxalate	
BMI				
Underweight	Count	8	16	24
	Percentage within BMI	33.3	66.7	100.0
	Percentage within stone type	3.5	7.8	5.5
Normal weight	Count	41	40	81
	Percentage within BMI	50.6	49.4	100.0
	Percentage within stone type	18.1	19.4	18.7
Overweight	Count	84	53	137
	Percentage within BMI	61.3	38.7	100.0
	Percentage within stone type	37.0	25.7	31.6
Class I obesity	Count	57	51	108
	Percentage within BMI	52.8	47.2	100.0
	Percentage within stone type	25.1	24.8	24.9
Class II obesity	Count	27	26	53
	Percentage within BMI	50.9	49.1	100.0
	Percentage within stone type	11.9	12.6	12.2
Class III obesity	Count	10	20	30
	Percentage within BMI	33.3	66.7	100.0
	Percentage within stone type	4.4	9.7	6.9
Total	Count	227	206	433
	Percentage within BMI	52.4	47.6	100.0
	Percentage within stone type	100.0	100.0	100.0
P		0.03		

BMI: Body mass index

Table 6: Carbonate apatite stones in relation to body mass index, with the value of *P*

BMI	Percentage	Stone type		Total
		Carbonate apatite	Not carbonate apatite	
BMI				
Underweight	Count	11	13	24
	Percentage within BMI	45.8	54.2	100.0
	Percentage within stone type	7.6	4.5	5.5
Normal weight	Count	26	55	81
	Percentage within BMI	32.1	67.9	100.0
	Percentage within stone type	18.1	19.0	18.7
Overweight	Count	38	99	137
	Percentage within BMI	27.7	72.3	100.0
	Percentage within stone type	26.4	34.3	31.6
Class I obesity	Count	35	73	108
	Percentage within BMI	32.4	67.6	100.0
	Percentage within stone type	24.3	25.3	24.9
Class II obesity	Count	20	33	53
	Percentage within BMI	37.7	62.3	100.0
	Percentage within stone type	13.9	11.4	12.2
Class III obesity	Count	14	16	30
	Percentage within BMI	46.7	53.3	100.0
	Percentage within stone type	9.7	5.5	6.9
Total	Count	144	289	433
	Percentage within BMI	33.3	66.7	100.0
	Percentage within stone type	100.0	100.0	100.0
P		0.253		

BMI: Body mass index

Table 7: Cystine stones in relation to body mass index, with the value of *P*

BMI	Percentage	Stone type		Total
		Cystine	Not cystine	
BMI				
Underweight	Count	1	23	24
	Percentage within BMI	4.2	95.8	100.0
	Percentage within stone type	5.6	5.5	5.5
Normal weight	Count	10	71	81
	Percentage within BMI	12.3	87.7	100.0
	Percentage within stone type	55.6	17.1	18.7
Overweight	Count	2	135	137
	Percentage within BMI	1.5	98.5	100.0
	Percentage within stone type	11.1	32.5	31.6
Class I obesity	Count	1	107	108
	Percentage within BMI	0.9	99.1	100.0
	Percentage within stone type	5.6	25.8	24.9
Class II obesity	Count	2	51	53
	Percentage within BMI	3.8	96.2	100.0
	Percentage within stone type	11.1	12.3	12.2
Class III obesity	Count	2	28	30
	Percentage within BMI	6.7	93.3	100.0
	Percentage within stone type	11.1	6.7	6.9
Total	Count	18	415	433
	Percentage within BMI	4.2	95.8	100.0
	Percentage within stone type	100.0	100.0	100.0
P		0.03		

BMI: Body mass index

We observed stone recurrence in 52 patients, which would have increased the total sample size to 485. Forty-eight cases of recurrence were an initial recurrence, and four cases were the second recurrence. However, we did not include recurrence cases in our results to avoid bias.

DISCUSSION

Identifying the composition of the stones is a core element in the metabolic evaluation of urolithiasis. Globally, urolithiasis is considered a recurrent, painful, and common problem with major deleterious sequelae. High BMI is considered to be one cause of the global rise in the prevalence and incidence of urolithiasis among both males and females.[9]

In our study, we found that the incidence of stones was high in overweight and obese patients.[7,10-12] Indeed, 75.7%

Table 8: Uric acid stones in relation to body mass index, with the value of *P*

BMI	Percentage	Stone type		Total
		Not uric acid	Uric acid	
BMI				
Underweight	Count	24	0	24
	Percentage within BMI	100.0	0.0	100.0
	Percentage within stone type	6.0	0.0	5.5
Normal weight	Count	78	3	81
	Percentage within BMI	96.3	3.7	100.0
	Percentage within stone type	19.4	9.7	18.7
Over weight	Count	127	10	137
	Percentage within BMI	92.7	7.3	100.0
	Percentage within stone Type	31.6	32.3	31.6
Class I obesity	Count	97	11	108
	Percentage within BMI	89.8	10.2	100.0
	Percentage within stone type	24.1	35.5	24.9
Class II obesity	Count	49	4	53
	Percentage within BMI	92.5	7.5	100.0
	Percentage within stone type	12.2	12.9	12.2
Class III obesity	Count	27	3	30
	Percentage within BMI	90.0	10.0	100.0
	Percentage within stone type	6.7	9.7	6.9
Total	Count	402	31	433
	Percentage within BMI	92.8	7.2	100.0
	Percentage within stone type	100.0	100.0	100.0
P	0.395			

BMI: Body mass index

of our patients had a BMI of 25 or higher. An increase in the incidence of stones may result from certain metabolic changes related to obesity and the pathophysiology of stone formation. This issue has been discussed in many studies, which concluded that many risk factors for stone formation were observed in obese patients and linked to some types of stones.[13,14] Studies have demonstrated that obesity contributes to the excess excretion of urinary calcium, oxalate, sulfate, phosphate, sodium, and uric acid. However, the core element for stone formation is acidic urine.[7,15]

In this study, we compared the incidence of different types of stones in relation to BMI. According to our results, patients with a high BMI tended to have a higher incidence of calcium oxalate, uric acid, and carbonate apatite stones than those with a lower BMI. Calcium oxalate stones accounted for 52.4% of all stones in our study; approximately 41.4% of these stones were found in patients with a BMI above 30 and 37% were found in overweight patients. Approximately 60% of all uric acid stones were found in patients with a BMI above 30. Taylor and Curhan noted a significant association between BMI and uric acid supersaturation and formation.[7,16-18] Furthermore, obese patients are at higher risk than nonobese patients of gouty diathesis, which may further promote the formation of uric acid stones.[14,19] The high concentration of uric acid may lead to a decrease in the solubility of calcium oxalate, which might be associated with the reduced inhibitory activity of glycosaminoglycans on the crystallization of calcium oxalates, eventually resulting in the formation of calcium oxalate stones.[20]

Cystine stones generally account for 1%–2% of all kidney stones. In our study, we observed 18 cases of cystine stones, which accounted for 4.2% of all stones. Ten of the affected patients were of normal weight; these stones accounted for 55.6% of all the identified cystine stones. We could not find a clear explanation supporting this high incidence of cystine stones in normal-weight patients compared to that in patients in other BMI categories.

One of the strengths of our study is our use of FTIR for the analysis of kidney stones. FTIR has been proven to overcome many limitations associated with chemical analysis.[21]

In addition, unlike other studies, we classified the BMI of our patients according to the WHO classification. We were also able to discuss all three classes of obesity and their association with urinary tract stones.

One of the limitations of this study is the sample size. FTIR has only recently been implemented in the KKUH and has been used on fewer than 500 stones during the short usage period of 2 years.

Another limitation of this study is that some patients had missing data. Approximately seven patients were excluded from this study for this reason.

CONCLUSIONS

Patients with a higher BMI tend to have a higher chance of having stones composed mostly of calcium oxalate, carbonate apatite, or uric acid. The value of *P* for the association between the overall incidence of different urinary tract stones types and BMI in this study was 0.00382, which is highly significant and supports the use of BMI as a measure for predicting the incidence of different types of stones in Saudi Arabia.

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Conflicts of interest

There are no conflicts of interest.

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