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Research Article

Association of body mass index, urinary pH and urolithiasis

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ABSTRACT

Background: Urinary stones have afflicted mankind since antiquity, with earliest recorded being bladder and kidney stones detected in Egyptian mummies dated 4800 BC. In our study we aimed to determine the association of BMI, urinary pH and urolithiasis.
Methods: The study was conducted in the department of surgery, Gandhi Medical College, Bhopal. A total of 100 patients who underwent open surgical procedures for urolithiasis were included in the study. The study was carried out from October 2013 to October 2014. The data collected was analyzed for association of BMI with urinary pH, serum creatinine, serum uric acid and serum calcium. Also the effect of body mass index BMI on the chemical composition of stone was studied.
Results: A total of 100 patients of urolithiasis undergoing nephrolithotomy, pyelolithotomy or ureterolithotomy were included in the study. The patients were divided into three groups according to BMI as stated above. The result of inter group comparison showed a statistically significant increase in presence of calcium oxalate and uric acid stones with increasing BMI. The presence of calcium phosphate stone did not indicate any significant change with changing BMI.
Conclusions: Hyperinsulinemia and insulin resistance play an important role in etiology of uric acid stones, hence all patients with uric acid stones should be screened for diabetes.

Keywords: BMI, Urinary stones, Calcium phosphate, Hyperinsulinemia

INTRODUCTION

Urinary stones have afflicted mankind since antiquity; with earliest recorded being bladder and kidney stones detected in Egyptian mummies dated 4800 BC.

Urolithiasis is a multifactorial disease. The lifetime risk varies from 1%-5% in Asia to 20% - 25% in Middle East countries.[1] The prevalence of urolithiasis requiring medical or surgical intervention is 5% - 10% and is increasing worldwide there by burdening the society not just health wise but economically as well.[2] The factors implicated are age, sex, BMI, genetics, race, diet and water intake, climate and geographical variation.[3]

Most urinary stones are mixed stones and stones formed of a single element are rare.

Obesity is implicated in the alarming worldwide escalation of the prevalence of urinary stone disease.[4] Obesity has also been linked to many lithogenic factors such as increased BMI, hypercalciuria, hyperoxaluria, glucose intolerance and hyperinsulinemia.[5] Study by Duffey et al showed 80% of the morbidly obese patients had 3 or more lithogenic factors.[6]

The exact biochemical changes which favour stone formation in obese individuals are still not clear. Recent investigations have mentioned that obesity is related with

changes in the biochemical composition of urine including phosphate, oxalate, uric acid and citrate and more acidic urine favouring stone formation.[7-9] Increased BMI not only contributes to the increased prevalence of urinary stones but is also associated with larger stone size.

In our study we aimed to determine the association of BMI, urinary pH and urolithiasis.

METHODS

The study was conducted in the Department of Surgery, Gandhi Medical College, Bhopal. A total of 100 patients who underwent open surgical procedures for urolithiasis were included in the study. The study was carried out from October 2013 to October 2014.

The data included patient's name, age, sex, BMI, urinary pH, serum calcium, serum uric acid, serum creatinine and chemical composition of the stone.

BMI was calculated as weight in kilograms divided by height in meter square. The patients were divided into three groups according to WHO criteria of BMI.

- Group I normal (BMI 18.5-24.9)
- Group II overweight (BMI 25-29.9)
- Group III obese (BMI>=30)

Radiological workup included plain x-ray KUB, USG, IVP. All patients were operated under general/spinal anaesthesia. Urine sample was collected from renal pelvis/ureter at the time of surgery and pH measured using pH meter.

The qualitative urinary stone analysis was done by "Three glass slide" technique as described by Kleeberg J.

Exclusion criteria

- Patients less than twelve years of age
- Patients with history of gout
- History of hyperparathyroidism
- Renal tubular acidosis
- Patients with recurrent renal calculi

The data collected was analyzed for association of BMI with urinary pH, serum creatinine, serum uric acid and serum calcium. Also the effect of BMI on the chemical composition of stone was studied.

The study was conducted after approval from the ethical committee of Gandhi Medical College, Bhopal.

RESULTS

A total of 100 patients of urolithiasis undergoing nephrolithotomy, pyelolithotomy or ureterolithotomy were included in the study. The patients were divided into three groups according to BMI as stated above. There were 32 patients in group I (normal BMI), 38 in group II (overweight) and 30 in group III (obese).

There were 33 females and 67 males in the study. Group I had 8 females and 24 males, group II had 13 females and 25 males and group III had 12 females and 18 males.

The mean age of the patients in group I was 34.3±9.5 years, in group II 34.1±10.39 years, in group III 34.9±10.5 years (p>0.05).

The mean value of urinary pH in BMI groups I, II and III were 7.47, 6.92 and 6.23 respectively showing a gradual decreasing pattern (Table 1).

Table 1: Urinary, serum creatinine, serum uric acid and serum calcium levels of the groups.

BMI groups		Urinary pH	S. Creatinine (mg%)	S. Uric acid (mg%)	S. Calcium (mg%)
I	Mean±SD	7.47±0.62	0.87±0.23	4.53±0.67	9.50±0.80
II	Mean±SD	6.92±0.54	1.08±0.27	5.29±0.73	9.84±0.75
III	Mean±SD	6.23±0.77	1.27±0.45	6.27±0.98	9.83±0.87

The mean value of serum creatinine (mg %) in BMI groups I, II, and III were 0.87, 1.08 and 1.27 respectively showing a gradual increasing pattern (Table 1). The mean value of serum uric acid (mg %) in BMI groups I, II and III were 4.53, 5.29 and 6.27 respectively showing an increasing pattern (Table 1).

The mean value of serum calcium (mg %) in BMI groups I, II and III were 9.5, 9.84 and 9.83 respectively showing no particular difference (Table 1).

Table 2: Statistical analysis of various parameters studied.

BMI groups	Urinary pH	S. creatinine	S. uric acid	S. Calcium
I and II	p<0.001	p = 0.002	p<0.001	p = 0.071
II and III	p<0.001	p<0.001	p<0.001	p = 0.12
I and III	p<0.001	p = 0.37	p<0.001	p = 0.96

Inter group comparison of various serum and urinary parameters showed p-value of less than 0.05 for urinary pH, serum creatinine and serum uric acid thereby indicating that the change in values of these parameters in relation to BMI was significant. The comparison showed that a higher BMI was associated with a more acidic urinary pH and there was higher concentration of serum creatinine and serum uric acid with increasing BMI. However the serum calcium levels did not show any statistically significant difference (Table 2).

Table 3: Stone composition in the three groups.

BMI groups		Ca phosphate stone	Ca oxalate stone	Uric acid stone	Ammonium phosphate
I	32	16 (50%)	14 (43.8%)	2 (6.2%)	4 (12.5%)
II	38	20 (52.6%)	26 (68.4%)	10 (26.3%)	4 (10.5%)
III	30	16 (53.3%)	27 (90%)	15 (50%)	3 (10%)

The stone composition analysis of the various groups showed calcium phosphate to be commonest stone in group I while calcium oxalate was the commonest stone in groups II and III. 50% of patients in group III had uric acid stones in contrast to only 6.2% in group I (Table 3).

The result of inter group comparison showed a statistically significant increase in presence of calcium oxalate and uric acid stones with increasing BMI. The presence of calcium phosphate stone did not indicate any significant change with changing BMI (Table 4).

Table 4: Inter group statistical comparison of chemical composition of stone.

BMI groups	Ca phosphate stone	Ca oxalate stone	Uric acid stone	Ammonium phosphate
I and II	p = 0.94	p = 0.037	p = 0.014	p = 0.99
II and III	p = 0.96	p = 0.033	p = 0.044	p = 0.97
I and III	p = 0.96	p = 0.0001	p = 0.001	p = 0.94

DISCUSSION

Obesity has been linked with a higher prevalence of renal stones especially uric acid and calcium oxalate stones.[10] In two large study cohorts in the USA 'The Nurses' Health study I' or NHS I and the Health Professionals Follow-up Study or HPFS Curhan et al found the prevalence of stone history and incidence of stone episodes to be directly associated with BMI.[11]

In our study we also found a positive correlation between the occurrence of calcium oxalate and urate stones with higher BMI supporting the hypothesis that an elevated BMI is associated with an increased risk of calcium oxalate and uric acid stones.

Chou et al also found a higher risk of calcium oxalate and uric acid stones in obese patients. No such correlation was observed in patients with calcium phosphate stone. In the study by Chou the prevalence of calcium oxalate stones in obese patients was 34.9% compared to 23.1% in normal weight patients10. In our study 90% of obese and 43% of normal BMI patients had calcium oxalate stones. Chou et al found the prevalence of uric acid stone in obese patients 7.7% in contrast to 2.8% in normal BMI patients. Duadon et al found prevalence of uric acid stones 28.7% and 7% respectively in obese and normal weight patients where as in a study by Ekeruo et al the incidence was 63% and 11% in obese and normal weight patient's respectively.[12, 13] We found uric acid stones in 50% of obese patients and 6% of normal patients. No correlation was found between BMI and calcium phosphate stone in Chou's study as in our study. Najeeb et al in their study found a positive correlation between prevalence of calcium phosphate stones and BMI.[14]

The difference in the study may be due to the difference in the subset of population selected, different classification of BMI, difference in the methods of stone analysis in various studies and also different dietary habits.

The possible explanation for increased calcium oxalate and uric acid stones in patients with higher BMI may be that the urinary uric acid contributes substantially to the risk of calcium oxalate stone formation because high concentrations of uric acid leads to decreased solubility of calcium oxalate and might be associated with a reduced inhibitory activity of glycosaminoglycans on the crystallization of calcium oxalate.[15]

Obesity has been associated with a spectrum of metabolic abnormalities including dyslipidemia, hypertension, impaired carbohydrate tolerance, insulin resistance and hyperinsulinemia. These together with obesity form the Metabolic Syndrome. Study by Maalouf showed that the presence of increasing number of metabolic syndrome features augments the propensity of uric acid stone formation.[16] Insulin resistance is a common feature in obesity, type 2 diabetes and metabolic syndrome and is thought to cause the overtly acidic urine in these patients. Hyperinsulinemia could also lead to decreased urinary citrate, increased urinary excretion of calcium, uric acid and oxalate which are important risk factors for nephrolithiasis.[17]

We found that urinary pH significantly decreases with increasing body weight. This inverse correlation was also observed by Chou et al and Najeeb et al in their respective studies. The reason for this inverse relationship may be insulin resistance which decreases renal ammonia excretion and impairs hydrogen ion buffering and thus affecting urinary ph.[18,19]

In our study serum creatinine and serum uric acid concentration was strongly correlated with BMI whereas no such correlation was observed between serum calcium and BMI. Similar results were observed by Siener et al.[20] The possible explanation for increased serum uric acid concentration in overweight and obese patients is mainly attributed to a slightly impaired renal clearance of uric acid rather than overproduction.

In our study we found the sex wise incidence of stone disease in the patients was 67% males and 33% females, the ratio was ~ 2:1 which is consistent with overall incidence ratio of kidney stone disease.

Finally in our study 68% of subjects had BMI more than normal supporting the evidence that renal stone disease is more common in higher BMI patients.[11]

A limitation of this study was the small sample size. The subjects included were those who underwent surgery for urinary calculi representing a very small subset of population.

Another limitation was the use of wet chemical analysis for urinary stone qualitative analysis. The gold standard for urinary stone qualitative analysis is infrared spectrometry and X-ray diffraction which were not available.

Nevertheless given the observations in our study we found that BMI plays a pivotal role in urinary stone disease and weight reduction and a lower BMI may be a preventive measure for urinary stones.

CONCLUSION

Obesity is one of the important and modifiable risk factors in etiology of urinary stones. In our study we found inverse relationship between urinary pH and BMI among patients with urolithiasis and a higher occurrence of uric acid and oxalate stone patients with higher BMI. Lifestyle modification for weight reduction and normal BMI will help reduce prevalence of urinary stone in general population. Hyperinsulinemia and insulin resistance play an important role in etiology of uric acid stones, hence all patients with uric acid stones should be screened for diabetes.

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