Urol Res (2011) 39:283–287
DOI 10.1007/s00240-010-0344-8

ORIGINAL PAPER

Difference in urinary stone components between obese and non-obese patients

Yii-Her Chou · Ching-Ming Su · Ching-Chia Li · Chia-Chu Liu · Mu-En Liu · Wen-Jeng Wu · Yung-Shun Juan

Received: 21 April 2010 / Accepted: 8 November 2010 / Published online: 16 December 2010

Abstract The prevalence and incidence of urinary stone disease have been reported to be associated with body weight and body mass index (BMI). The aim of the study was to determine the difference in stone components among different BMI groups in patients with urolithiasis. Between Dec 2005 and Jan 2008, 907 urinary calculi were collected and analyzed by infrared spectroscopy. Most of the stones had been passed spontaneously, and some were collected during surgical manipulations. The data on patients' gender, age, BMI at diagnosis, and stone composition were collected. The patients were classified as normal weight (18.5≤ BMI <24), overweight (24≤ BMI <27), or obese (BMI ≥27). Of the 907 patients with urinary stone disease, 27.7% had normal weight, 33.5% were overweight, and 38.8% were obese. The prevalence of calcium oxalate stones in the normal weight, overweight, and obese groups were 23.1, 30.6, and 34.9%, respectively ($P = 0.002$), and the prevalence of uric acid stones in the different groups was 2.8, 7.2, and 7.7%, respectively ($P = 0.002$). The prevalence of calcium oxalate and uric acid stones, but not that of calcium phosphate stones, increased with body size. There was a significant correlation between BMI and uric acid stones in the overweight and obesity groups, with odds ratios of 3.28 and 4.35, respectively. The prevalence and incidence of urinary stone disease were found to be associated with BMI. The percentage of uric acid and calcium oxalate stones was higher in obese than in non-obese patients. There was no apparent difference in the prevalence of calcium phosphate stones between obese and non-obese patients.

Keywords Stone components · Urolithiasis · Obesity · Calcium phosphate · Calcium oxalate · Uric acid

Y.-H. Chou (✉) · C.-C. Li · C.-C. Liu · W.-J. Wu · Y.-S. Juan
Department of Urology, Faculty of Medicine,
College of Medicine, Kaohsiung Medical University Hospital,
No. 100 Tzyou 1st Road, Kaohsiung 807, Taiwan
e-mail: yihech@kmu.edu.tw

C.-M. Su
Department of Urology, Kaohsiung Municipal United Hospital,
Kaohsiung, Taiwan

M.-E. Liu
Graduate Institute of Medical Genetic,
Kaohsiung Medical University, Kaohsiung, Taiwan

Introduction

Urinary stone disease has multifactorial causes that have not been completely understood. The prevalence of this disease has been increasing in the United States, as well as in other countries, along with the increase in the rate of obesity across many nations [1–4]. The prevalence and incidence of urinary stone disease have been reported to be associated with body weight and body mass index (BMI) [5–7]. The aim of this study was to determine whether there is difference in the components of urinary stones in obese and non-obese patients with urolithiasis.

Materials and methods

Between 2003 and 2008, 907 urinary stones were collected from 907 patients with urolithiasis admitted at two hospitals in subtropical southern Taiwan. All stone specimens were analyzed by infrared spectroscopy. The diagnosis of urolithiasis was made on the basis of clinical examination, ultrasonography, plain X-ray, intravenous urography, and computed tomography. In most of the patients, stones had been passed spontaneously, with or without requiring extracorporeal shock wave lithotripsy. In some patients, stones were collected during surgical manipulations, including ureterorenoscopic lithotripsy (URSL), percutaneous nephrolithotripsy (PCNL), cystolitholapaxy, or open surgery. Clinical data included patients' gender, age, BMI, and urinary stone composition. The patients were classified as normal weight ($18.5 \leq$ BMI <24), overweight ($24 \leq$ BMI <27), or obese (BMI ≥ 27). BMI was calculated using the following equation: weight (kg)/[height]^2 (m^2). The definitions of normal weight, overweight, and obesity for Asian population were established by the World Health Organization (WHO) in 2002 [8]. For statistical analysis, the percentage of different stone components across different BMI groups was compared using the Chi-square method. P values of <0.05 were considered statistically significant.

Results

The patients included 661 men (72.9%) and 246 women (27.1%). Their mean age and BMI were 53.9 years and 25.7 kg/m^2, respectively. Of the patients, 27.7% had normal weight, 33.5% were overweight, and 38.8% were obese. Of the 907 patients, 274 (30.2%) had calcium oxalate stones, 89 (9.8%) had calcium phosphate stones, 488 (53.8%) had mixed calcium oxalate and calcium phosphate stones, and 56 (6.2%) had uric acid stones (Table 1). The distribution of different stone components, including calcium oxalate, calcium phosphate, mixed calcium, and uric acid, was 215 (32.5%), 44 (6.7%), 351 (53.1%), and 51 (7.7%) cases, respectively, in male patients and 59 (24.0%), 45 (18.3%) 137 (55.7%), and 5 (2.0%), respectively, in female patients. The percentage of calcium oxalate and uric acid stones was markedly higher in male patients than in female patients. On the other hand, the percentage of calcium phosphate stones was significantly higher in female patients than in male patients ($P < 0.001$) (Table 2). The relationship of different urinary stone components and different BMI groups was as follows. Calcium oxalate stones were found in 23.1, 30.6, and 34.9% of the normal weight, overweight, and obese groups, respectively ($P = 0.002$). Uric acid stones were found in 2.8, 7.2, and 7.7% of the three BMI groups ($P = 0.002$). The stone components were significantly different among the normal weight, overweight, and obese groups. Patients with higher BMI tended to have greater percentage of uric acid and calcium oxalate stones but lower percentage of calcium phosphate stones (Table 3). The multiple logistic regression model, including factors such as age, sex, and body size, for predicting the relationship between uric acid stone components and BMI revealed a significant correlation in the overweight and obesity groups, with odds ratios of 3.28 and 4.35, respectively (Table 4).

Discussion

Risk factors for stone formation and recurrence include positive family history, nutritional factors, nutritional deficiencies, life style factors, stone episodes, and other disease states [9, 10]. Recent studies have suggested that an increased prevalence of urolithiasis and recurrence is associated with obesity [11–16]. A high BMI is known to be associated with the risk of urolithiasis not only in male adults but also in children and female patients; it is also responsible for the change in gender prevalence of urinary stone disease [17–19].

Obesity, an important public health problem in most countries, is associated with chronic medical conditions such as hypertension, hyperlipidemia, hypercholesterolemia, diabetes mellitus, cardiovascular disease, and other medical problems. The prevalence of urinary stone disease is higher in overweight or obese individuals. Recent studies have revealed that obesity is associated with changes in the chemical components of serum and urine, such as citrate, phosphate, oxalate, and uric acid. This metabolic change may explain the association between obesity and urinary stone disease [20].

Urinary stones have different components such as calcium oxalate, calcium phosphate, uric acid, struvite, and mixed components. Is obesity related to the formation of every kind of urinary stone? The correlation between stone component and increasing prevalence of urolithiasis from obesity is not well-documented. The mechanism underlying this relationship is not clear. The advantage of our

Table 1 Characteristics of study population

Characteristics	N (%)	Mean (SD)	Range
Patient number	907		
Age (years)		53.9 (13.5)	21–88
Sex			
Male	661 (72.9)		
Female	246 (27.1)		
BMI		25.7 (3.8)	15–41
<24	251 (27.7)		
24–27	304 (33.5)		
>27	352 (38.8)		
Stone components			
Calcium oxalate	274 (30.2)		
Calcium phosphate	89 (9.8)		
Mixed calcium	488 (53.8)		
Uric acid stone	56 (6.2)		

Table 2 Prevalence of stone components in different genders

	Calcium oxalate stones	Calcium phosphate stones	Mixed calcium stones	Uric acid stones	Total (%)
Male	215 (32.5)	44 (6.7)	351 (53.1)	51 (7.7)	661 (100)
Female	59 (24.0)	45 (18.3)	137 (55.7)	5 (2.0)	246 (100)

$P < 0.001$ by Chi-square test

Table 3 The relationship of body mass index and stone components

	Calcium oxalate stones	Calcium phosphate stones	Mixed calcium stones	Uric acid stones	Total (%)
BMI <24	58 (23.1)	30 (12.0)	156 (62.2)	7 (2.8)	251 (100)
24≤ BMI <27	93 (30.6)	31 (10.2)	158 (52.0)	22 (7.2)	304 (100)
BMI ≥27	123 (34.9)	28 (8.0)	174 (49.4)	27 (7.7)	352 (100)

$P = 0.002$ by Chi-square test

Table 4 The predicting factors for uric acid stone components in patients with urinary stone disease

	Odds Ratio	95% CI	*P* value
Age (years)	1.06	1.04–1.09	<0.001
Sex			
Female	Ref		
Male	4.56	1.77–11.78	0.002
Body size			
Normal weight (BMI <24)	Ref		
Overweight (24≤ BMI <27)	3.28	1.33–8.09	0.01
Obesity (BMI ≥27)	4.35	1.77–10.6	0.001

Multiple logistic regression analysis

BMI body mass index

study was that the stone analysis data for all the cases included in our study was available. The most common form of urinary stone found in our study group was mixed calcium oxalate with calcium phosphate stone, followed by calcium oxalate, calcium phosphate, and uric acid stones. Fourier transform infrared (FTIR) spectroscopy is a valuable method for stone analysis. When more than 70–80% of a urinary stone is composed of one type of crystal, the stone is named after that crystal. When two or more crystals are found at almost the same level in a stone, the stone is known as a mixed stone. On FTIR spectroscopy, uric acid crystals show a considerably complicated waveform with multiple peaks unlike that that for calcium oxalate crystals. A stone containing a mixture of calcium oxalate and uric acid is difficult to identify by FTIR spectroscopy because the peak for calcium oxalate crystals overlaps with that for uric acid crystals. Theoretically, in a stone with a mixture of calcium oxalate and uric acid crystals, the mechanisms of stone formation and prevention of stone recurrence are dependent more on uric acid metabolism than on calcium metabolism; hence, a stone with such a composition is classified as a uric acid stone in our study.

Our study shows that a higher BMI increases the prevalence of uric acid stones. Studies on several groups of individuals with nephrolithiasis have shown that higher weight is associated with a lower urinary pH [21]. Overweight or obese individuals also have a higher incidence of diabetes mellitus, which is correlated with hyperinsulinemia or insulin resistance. Insulin resistance may manifest as a kidney disease in the form of a defect in ammonium production and ability to excrete acid; it thus affects urinary pH [22–24]. Hyperinsulinemia may also decrease urinary citrate level and increase urinary excretion of uric acid and oxalate crystals, which are important risk factors for urinary stone formation [25–28]. Another possible reason is that overweight and obesity are associated with an increased risk of hyperuricosuria, which often results in increased uric acid excretion, an acidic urine environment, and uric acid stone formation. Urine pH is found to be reversely associated with BMI among Asian patients with urolithiasis [21].

Our results also show that a higher BMI increases the risk of calcium oxalate stone formation. Increased urinary uric acid excretion is not only associated with uric acid stone formation but also a risk factor for calcium oxalate stone formation because calcium oxalate stones may develop by the salting-out effect in a hyperuricosuria environment [29, 30]. Another reason for the increase in the incidence of calcium oxalate stone formation is that increase in BMI leads to a decrease in urine pH; the formation of calcium phosphate stones, and not calcium oxalate stones, is dependent more on the urine pH. Decrease in urine pH leads to the decrease in the production of calcium phosphate crystals, which results in a relative increase in the formation of calcium oxalate stones.

Our results revealed that the prevalence of calcium oxalate and uric acid stones is directly correlated with body size (BMI). The model of multiple logistic regression models, including factors such as age, sex, and body size, to predict the relationship between uric acid stone components and

BMI revealed that the incidence of uric acid stones is higher in obese individuals than in non-obese individuals.

The interesting finding of our study is that a higher BMI was not found to increase the formation of calcium phosphate stones. Obesity appears to affect urinary excretion of potential lithogenic factors such as oxalate and uric acid, but not calcium [31, 32]. The formation of calcium phosphate stones is correlated more with calcium metabolism factors such as hyperparathyroidism, which may explain why the incidence of calcium phosphate stones is not higher in obese individuals. Further study is necessary to detect the exact mechanism underlying the correlations between urinary stone disease and BMI.

For stone prevention, a typical method is to manipulate the levels of chemical components in urine, such as sodium, citrate, oxalate, uric acid, and calcium. Weight control, adequate physical activity, balanced diet, and sufficient fluid intake are easy and inexpensive ways of preventing stone formation. Weight control in obese patients can theoretically restore abnormal urine metabolites and probably reduce stone episodes but further data is needed to support this hypothesis.

The present study had limitations. The urine and serum biochemical profiles of the patients were not available; also in addition, the role of diabetes mellitus, which may have some role in the formation of stone component, was not discussed in this study.

Conclusion

The prevalence and incidence of urinary stone disease are associated with BMI. The percentage of uric acid and calcium oxalate stones is higher in obese individuals than in non-obese individuals. There is no apparent difference in the incidence of calcium phosphate stones between obese and non-obese patients.

This finding suggests that clinicians should encourage urinary stone patients to reduce weight, especially those with calcium oxalate and uric acid urinary stones.

Acknowledgments The authors thank the Statistical Analysis Laboratory, Department of Medical Research, Kaohsiung Medical University Hospital, Kaohsiung Medical University for the help they provided. The authors also thank Miss Ai-Wen Chang and Miss Mei-Hui Lee for preparation and collection of stone analysis data.

Conflict of interest The authors have nothing to declare.

References

1. Stamatelou KK, Francis ME, Jones CA, Nyberg LM, Curhan GC (2003) Time trends in reported prevalence of kidney stones in the United States: 1976–1994. Kidney Int 63:1817–1823
2. Johnson CM, Wilson DM, O'Fallon WM, Malek RS, Kurland LT (1979) Renal stone epidemiology: a 25-year study in Rochester, Minnesota. Kidney Int 16:624–631
3. Yoshida O, Terai A, Ohkawa, Okada Y (1999) National trend of the incidence of urolithiasis in Japan from 1965 to 1995. Kidney Int 56:1899–1904
4. Curhan GC, Willett WC, Rimm EB, Speizer FE, Stampfer MJ (1998) Body size and risk of kidney stones. J Am Soc Nephrol 9:1645–1652
5. Flegal KM, Carroll MD, Ogden CL, Johnson CL (2002) Prevalence and trends in obesity among US adults 1999–2000. JAMA 288:1723–1727
6. Kopelman PG (2000) Obesity as a medical problem. Nature 404:635–643
7. Taylor EN, Stampfer MJ, Curhan GC (2005) Obesity, weight gain, and the risk of kidney stones. JAMA 293:455–462
8. Choo V (2002) WHO reassesses appropriate body-mass index for Asian populations. Lancet 360:235
9. Coe FL, Parks JH, Asplin JR (1992) The pathogenesis and treatment of kidney stones. N Engl J Med 327:1141–1152
10. Levy FL, Adams-Huet B, Pak CY (1995) Ambulatory evaluation of nephrolithiasis: an update of a 1980 protocol. Am J Med 98:50–59
11. Lee SC, Kim YJ, Kim TH, Yun SJ, Lee NK, Kim WJ (2008) Impact of obesity in patients with urolithiasis and its prognostic usefulness in stone recurrence. J Urol 179:570–574
12. Sarica K, Altay B, Erturhan S (2008) Effect of being overweight on stone-forming risk factors. Urology 71:771–774
13. Duffey BG, Pedro RN, Kriedberg C, Weiland D, Melquist J, Ikramuddin S et al (2008) Lithogenic risk factors in the morbidly obese population. J Urol 179:1401–1406
14. Obligado SH, Goldfarb DS (2008) The association of nephrolithiasis with hypertension and obesity: a review. Am J Hypertens 21:257–264
15. Zilberman DE, Yong D, Albala DM (2009) The impact of societal changes on patterns of urolithiasis. Curr Opin Urol 20:148–153
16. Asplin JR (2009) Obesity and urolithiasis. Adv Chronic Kidney Dis 16:11–20
17. Eisner BH, Eisenberg ML, Stoller ML (2009) Influence of body mass index on quantitative 24-hour urine chemistry studies in children with nephrolithiasis. J Urol 182:1142–1145
18. Scales CD Jr, Curtis LH, Norris RD, Springhart WP, Sur RL, Schulman KA et al (2007) Changing gender prevalence of stone disease. J Urol 177:979–982
19. Strope SA, Wolf JS Jr, Hollenbeck BK (2009) Changes in gender distribution of urinary stone disease. Urology 75:543–546
20. Powell CR, Stoller ML, Schwartz BF, Kane C, Gentle DL, Bruce JE et al (2005) Impact of body weight on urinary electrolytes in urinary stone former. Urology 55(6):825–830
21. Li WM, Chou YH, Li CC, Liu CC, Huang SP, Wu WJ et al (2009) Association of body mass index and urine pH in patients with urolithiasis. Urol Res 37:193–196
22. Maalouf NM, Sakhaee K, Parks JH, Coe FL, Adam-Huet B, Pak CY (2004) Association of urinary pH with body weight in nephrolithiasis. Kidney Int 65:1422–1425
23. Sakhaee K, Maalouf NM (2008) Metabolic syndrome and uric acid nephrolithiasis. Semin Nephrol 28:174–180
24. Cameron MA, Sakhaee K (2007) Uric acid nephrolithiasis. Urol Clin North Am 34:335–346
25. Kamel KS, Cheema-Dhadli S, Halperin ML (2002) Studies on the pathophysiology of the low urine pH in patients with uric acid stones. Kidney Int 61:988–994
26. Abate N, Chandalia M, Cabo-Chan AV Jr, Moe OW, Sakhaee K et al (2004) The metabolic syndrome and uric acid nephrolithiasis: novel features of renal manifestation of insulin resistance. Kidney Int 65:386–392

27. Daudon M, Traxer O, Conort P, Lacour B, Jungers P (2006) Type 2 diabetes increases the risk for uric acid stones. J Am Soc Nephrol 17:2026–2033
28. Pak CY, Sakhaee K, Moe O, Preminger GM, Poindexter JR, Peterson RD et al (2003) Biochemical profile of stone-forming patients with diabetes mellitus. Urology 61:523–527
29. Grases F, Sanchis P, Perello J, Maser-Gluth C, Remer T (2006) Role of uric acid in different types of calcium oxalate renal calculi. Int J Urol 13:252–256
30. Grover PK, Ryall RL (2005) Critical appraisal of salting-out and its implications for chemical and biological sciences. Chem Rev 105:1–10
31. Shi L, Berkemeyer S, Buyken AE, Maser-Gluth C, Remer T (2010) Glucocorticoids and body fat associated with renal uric acid and oxalate, but not calcium excretion, in healthy children. Metabolism 59(1):134–139
32. Negri AL, Spivacow FR, Del Valle EE, Forrester M, Rosende G, Pinduli I (2008) Role of overweight and obesity on the urinary excretion of promoters and inhibitors of stone formation in stone formers. Urol Res 36:303–307