Urologia Internationalis

Research Article

Urol Int
DOI: 10.1159/000542255

Received: April 27, 2024
Accepted: October 8, 2024
Published online: April 4, 2025

Bladder Stone Composition in Jiangsu Region of China: Results from 421 Stone Analyses

Chen Zhu Long Ma Xuehua Chen Yue Zhou Yunfei Wei Ping Zhou Ninghong Wang Jian Su Lin Yuan Yan Xu

Department of Urology, Affiliated Hospital of Nanjing University of Chinese Medicine, Nanjing, China

Keywords

Bladder stone · Stone component · Infrared spectroscopy

Abstract

Introduction: Accurate analysis of bladder stone composition is essential for appropriate treatment planning and recurrence prevention. The aim of this study was to evaluate the characteristics of bladder stone components in our center. ***Methods:*** A retrospective analysis on the composition of bladder stones collected in our center from January 2014 to March 2023 was conducted in the present work. Age, sex, and laboratory examination of all patients were collected. Infrared spectroscopy was conducted for stone analysis. ***Results:*** The most common stone component was calcium oxalate (43.0%), followed by uric acid (UA) stone (35.4%), calcium phosphate (12.10%), infection stone (9.0%), and cystine (0.5%). The highest stone prevalence appeared in patients aged over 60 years and increased progressively with age. Furthermore, patients with UA stones were more likely to have a lower urinary pH. Additionally, patients with infection stones showed higher incidence of urinary tract infections than those with other types of stones. Patients with UA stones had higher average serum UA and creatinine levels. UA stones are more likely to form multiple stones compared to stones of other composition. The volume of infectious stones is larger compared to stones of other compositions. ***Conclusion:*** This study highlights the importance of gaining a deeper understanding of bladder stone composition, as it can lead to more effective evaluation, treatment, and prevention of stone disease.

Introduction

Bladder stone is a rare disease accounting for 5% of all urinary calculi [1, 2]. Primary bladder stones are relatively common in children and can be caused by dietary factors [3, 4]. Secondary bladder stones are associated with incomplete bladder emptying, which can increase the likelihood of both stone formation and retention [5]. Migratory bladder stones form in the upper urinary tract before moving into the bladder [6]. The composition of bladder stones may be affected by a variety of factors, including dietary patterns, geographic location, socioeconomic status, infections, anatomical abnormalities of the urinary tract, and metabolic disorders [6, 7].

Chen Zhu, Long Ma, and Xuehua Chen contributed equally to this work.

karger@karger.com
www.karger.com/uin

Correspondence to:
Yan Xu, yfy132@njucm.edu.cn

Understanding the stone composition can help guide the best therapeutic approach for each patient.

Our center is one of the largest urinary stone management institutions in East China. The present retrospective study was conducted to analyze the composition of bladder stones in East China, primarily in Jiangsu province. The aim of this study was to analyze the relationships of gender, age, and clinical characteristics with stone composition.

Methods

Patients

From January 2014 to March 2023, patients diagnosed with bladder stones at our center were included in this study. A total of 421 bladder stone specimens were collected, all of which were obtained intraoperatively, including transurethral cystolithotripsy, and laparoscopic or open surgery. Clinical information and demographic data were collected from all patients. Online supplementary Table 1 (for all online suppl. material, see https://doi.org/10.1159/000542255) shows the demographic data of all the enrolled patients.

Calculus Classification

The predominant stone components were recorded and classified according to Mayo Clinic stone classification practices and EAU guidelines [8], including calcium oxalate (CaOx) stones, calcium phosphate (CaP) stones, uric acid (UA) stones, infection stones, and cystine stones.

Calculus Analysis Process

All calculi were analyzed by Fourier transform infrared spectroscopy at our center. First, the stones were washed and air-dried naturally or dried at 50°C. Next, 1 mg of the powdered stone specimen was mixed with 200 mg of dried potassium bromide. The mixture was then placed in an agate mortar and ground thoroughly until a fine powder with a diameter of less than 2 μm was formed. Afterward, the mixed powder was transferred into a mold and a tablet press machine was used to prepare the semitransparent thin slices at a pressure of 10–15 MPa for tests with an infrared spectroscopy analyzer. The instruments used in this study included the SUN-3G Intelligent Stone Analyzer from Dingshun (JiNan) Medical Equipment Co., Ltd.

Statistical Analysis

All parameters were presented as frequency or mean ± standard deviation. Chi-square test was conducted to analyze differences in categorical variables between the groups. One-way ANOVA was adopted to compare the blood chemical values among diverse stone groups. All statistical analyses were carried out using SPSS 13.0. p value <0.05 was considered statistically significant.

Results

A total of 421 patients with bladder stones were analyzed in our study, of which 402 (95.6%) were males, with a male-to-female ratio of 21:1. The age of patients ranged from 3 to 92 years, with an average of 66.90 ± 13.24 years. Among them, 322 patients were over 60 years old (online suppl. Table 1). All patients underwent surgical treatment. A total of 415 patients underwent transurethral cystolithotripsy, 5 patients underwent open cystolithotomy, and 1 patient underwent percutaneous cystolithotripsy.

Stone Composition

Of the 421 bladder stone specimens, 161 (38.2%) were composed of a single component, 140 (33.3%) were comprised by two components, and 120 (28.5%) consisted of three or more components (Table 1). CaOx was detected in 279 (66.3%) of the total stones, CaP in 218 (51.2%) stones, and UA in 149 (35.4%) stones. CaOx was the main component in 181 (43.0%) stones, while UA was the main component in 149 (35.4%) stones. The remaining main stone compositions included infection stone 38 (9.0%), CaP 51 (12.10%), and cystine 2 (0.5%) (Table 2).

To investigate the impact of age on stone composition, patients were categorized into four groups, including 1–20 years, 19–40 years, 41–60 years, and over 60 years. The highest stone prevalence appeared in patients over 60 years old and increased progressively with age. Among patients aged over 60 years, the most common stone composition was CaOx, followed by UA, CaP, and infectious stones. There was a significant difference in the incidence of bladder stones between males and females. The most common type of stones in male patients is CaOx, followed by UA, CaP, infectious stones, and cystine stones. In females, the most common type of stones was infectious stones, followed by CaOx and CaP stones, and UA stones. For patients with UA stones, they were more likely to have lower urinary pH levels. Additionally, patients with infection stones displayed a higher incidence rate of urinary tract infections (UTIs) than those with other types of stones (Table 3).

Table 1. The distribution of stones composed of single or multiple components

Composition, *n* (%)	*n*	Composition, *n* (%)	*n*	Composition, *n* (%)	*n*
COM	38	COD/carbapatite	17	COM/COM/carbapatite	7
Anhydrous UA	109	Struvite/carbapatite	13	Struvite/ammonium acid urate/carbapatite	6
COD	1	Carbapatite/COD	15	Struvite/carbapatite/COD	5
Dihydrate UA	2	Anhydrous UA/COM	38	Struvite/carbapatite/COM/COD	7
Ammonium urate	3	COM/COD	8	Ammonium acid urate/carbapatite/COM	1
Struvite	1	COM/carbapatite	47	Carbapatite/COD/COM	4
Brushite	4	Ammonium acid urate/carbapatite	1	Carbapatite/COM/COD	27
Amorphous CaP	1	Ammonium acid urate/COM	1	COM/COD/carbapatite	59
Cystine	2			COM/carbapatite/COD	4
Overall	161		140		120

Table 2. The distribution of main urinary stone composition

Compositions	Patients, *n*
CaOx	181
CaOx-monohydrate	156
CaOx-dihydrate	25
CaP	51
Carbapatite	50
Amorphous CaP	1
Infection stone	38
Struvite	32
Ammonium acid urate	6
Urate stone	149
Anhydrous UA	147
UA dihydrate	2
Cystine	2
Overall	421

The CT scans assessed stone size (mm), stone volume (mm^3), and the number of stones. Stone volume was the sum of each stone volume (0.52 × length × width × height). We found that infectious stones had the largest volume, followed by UA stones. UA stones are more likely to develop multiple stones compared to other compositions (Table 3).

Compared with patients with other types of stones, patients with UA stones showed higher average serum UA and creatinine levels. However, there were no significant differences in other serum variables such as calcium, potassium, phosphorus, calcium, and sodium, as shown in Table 4.

Discussion

The incidence of urolithiasis shows a steadily increasing trend in the last few decades. Although bladder stones account for only a small proportion of urolithiasis, they still affect the health of elderly men [1, 9]. In this study, we retrospectively analyzed the records of bladder stone composition and the relationships with clinical data in our center over the past 10 years.

The incidence of bladder stones is indeed higher in male patients than in females. This is primarily due to the anatomical differences in the male urinary system, making male patients more susceptible to lower urinary tract obstructions [10]. In the present study, the male-to-female ratio of bladder stone prevalence was 21:1, which exceeds the ratios reported in previous studies [7, 11].

In our study, although CaOx stones were the most common component (43.0%), the results were significantly lower than the data reported in previous national urine stone composition analyses, which found that CaOx stones accounted for approximately 60.7% of cases [7]. UA stones are second only to calcium-containing stones in terms of the prevalence. In our research, UA stones were observed in 35.4% of cases, and such figure was apparently higher than previous data (16.1%) [7]. Urinary pH is a pivotal factor for UA crystallization [12]. In this study, patients with UA stones were more likely to have lower urine pH values. At the same time, UA stones were found to be associated with elevated serum creatinine and UA levels. This suggests a potential association between UA stone formation and the impaired kidney function or increased UA production. The elevated serum creatinine levels may indicate the reduced kidney function, which

Table 3. Characteristics of patients stratified by stone composition

Characterization	n	Compositions					p value
		CaOx	CaP	struvite	UA	cystine	
Age							0.000
1–18 years	4	0	1	2	0	1	
19–40 years	14	5	5	3	1	0	
41–60 years	81	41	14	10	16	0	
≥60 years	322	135	31	23	132	1	
Gender							0.000
Male	402	177	48	28	147	2	
Female	19	4	3	10	2	0	
Hypertension							0.135
Yes	205	100	25	15	64	1	
No	216	81	26	23	85	1	
Diabetes							0.213
Yes	62	34	6	2	20	0	
No	359	147	45	36	129	2	
Urine pH							0.000
Acidity	356	147	43	26	139	1	
Neutral or alkaline	54	30	5	10	8	1	
Urinary infection							0.000
Yes	216	90	35	33	58	0	
No	194	88	13	3	88	2	
Patients with CT scans	239	111	24	24	80	0	
Solitary stone	145	76	19	16	34		0.001
Multiple stones	94	35	5	8	46		
Stone volume, mm^3		1,935.82±2,851.46	2,693.92±2,513.71	8,264.13±13,317.73	4,432.95±5,594.31		

Table 4. Serum biochemical values of all type stones forming individuals

Serum biochemical	Compositions				p value
	CaOx	CaP	infection stone	UA	
Urate, mmol/L	343.74±77.24	310.18±74.18	352.16±100.60	382.45±99.15	0.000
Creatinine, μmol/L	82.79±29.00	84.12±48.10	81.28±37.07	96.19±48.64	0.014
Potassium, mmol/L	3.81±0.34	3.90±0.39	3.80±0.37	3.94±0.41	0.01
Phosphorus, mmol/L	0.93±0.92	1.00±1.00	1.01±0.17	0.94±0.14	0.003
Calcium, mmol/L	2.31±0.18	2.34±0.17	2.29±0.24	2.28±0.14	0.192
Sodium, mmol/L	140.48±1.94	140.35±2.12	140.88±1.56	140.74±2.59	0.505

can contribute to UA accumulation and UA stone formation. Similarly, higher UA levels in the blood can increase the risk of UA stone formation, as UA can crystallize and precipitate in the urinary tract. These findings highlight the importance of monitoring serum Cr and UA levels in individuals at risk of UA stone formation. Urine alkalinization can reduce the formation and recurrence of UA stones, and decrease the chances of a secondary surgery. We also found that UA stones are more likely to form multiple stones compared to stones of other composition. This is because UA is more prone to precipitation in an acidic environment, leading to the simultaneous formation of crystallization cores at multiple sites in the urine, resulting in the appearance of multiple cores [13].

In accordance with other reports, our study discovered a higher proportion of infection stones among females than males [14]. Indeed, while the overall incidence of bladder stones is lower in females, it is noteworthy that infectious stones are the most common main component of bladder stones in females. Infections, particularly UTIs, can contribute to the formation of stones in the bladder. The female anatomy, with a shorter urethra, makes women more susceptible to UTIs, which can lead to the deposition of infectious agents and the subsequent development of stones. In our study, the volume of infectious stones is larger compared to stones of other compositions, which may be related to the rapid growth rate of infectious stones.

Although a considerable number of cases were included in this study, certain limitations should be noted in this study. First, the predominant source of stone specimens was surgical patients, which introduced a potential bias. Second, the scope of this study was confined to a single center; as a result, future research is warranted to encompass multiple centers. Moreover, the findings only represent the distribution characteristics of bladder stones in the Central China region. Lastly, the missing data somewhat compromised the precision of our results.

Conclusions

In summary, this study presented the analysis of bladder stone composition in East China, primarily in Jiangsu province. The results showed that CaOx was the most prevalent main component of bladder stones. Following calcium-containing stones, UA stones were the second most common type. Additionally, we found a strong correlation between the clinical characteristics and the types of stones. This study highlights the importance of gaining a deeper understanding of bladder stone composition, since it contributes to the more effective evaluation, treatment, and prevention of stone disease.

Acknowledgments

The authors would like to thank all our participants in this study.

Statement of Ethics

Ethical approval and consent were not required as this study was based on publicly available data. This study did not require Institutional Review Board approval of Affiliated Hospital of Nanjing University of Chinese Medicine.

Conflict of Interest Statement

None of the authors have any conflicts of interest or financial relationships.

Funding Sources

The authors did not receive support from any organization for the submitted work.

Author Contributions

C.Z. and L.M. performed conception and design of the experiments, and writing of manuscript; Y.Z., X.C., Y.W., P.Z., and N.W. provided data collection, analysis, and interpretation of data; J.S., L.Y., and Y.X. prepared writing and revision of the article.

Data Availability Statement

The data that support the findings of this study are not publicly available due to their containing information that could compromise the privacy of research participants. Further inquiries can be directed to the corresponding author.

References

1 Schwartz BF, Stoller ML. The vesical calculus. Urol Clin North Am. 2000;27(2):333–46. https://doi.org/10.1016/s0094-0143(05)70262-7

2 Kittanamongkolchai W, Vaughan LE, Enders FT, Dhondup T, Mehta RA, Krambeck AE, et al. The changing incidence and presentation of urinary stones over 3 decades. Mayo Clin Proc. 2018;93(3):291–9. https://doi.org/10.1016/j.mayocp.2017.11.018

3 Serdaroğlu E, Aydoğan M, Özdemir K, Bak M. Incidence and causes of urolithiasis in children between 0–2 years. Minerva Urol Nefrol. 2017;69(2):181–8. https://doi.org/10.23736/S0393-2249.16.02675-8

4 Ashworth M. Endemic bladder stones. BMJ. 1990;301(6756):826–7. https://doi.org/10.1136/bmj.301.6756.826

5 Van Koeveringe GA, Rademakers KL. Factors impacting bladder underactivity and clinical implications. Minerva Urol Nefrol. 2015; 67(2):139–48.
6 Childs MA, Mynderse LA, Rangel LJ, Wilson TM, Lingeman JE, Krambeck AE. Pathogenesis of bladder calculi in the presence of urinary stasis. J Urol. 2013;189(4):1347–51. https://doi.org/10.1016/j.juro.2012.11.079
7 Ye Z, Zeng G, Yang H, Li J, Tang K, Wang G, et al. The status and characteristics of urinary stone composition in China. BJU Int. 2020; 125(6):801–9. https://doi.org/10.1111/bju.14765
8 Skolarikos A, Straub M, Knoll T, Sarica K, Seitz C, Petřík A, et al. Metabolic evaluation and recurrence prevention for urinary stone patients: EAU guidelines. Eur Urol. 2015; 67(4):750–63. https://doi.org/10.1016/j.eururo.2014.10.029
9 Philippou P, Moraitis K, Masood J, Junaid I, Buchholz N. The management of bladder lithiasis in the modern era of endourology. Urology. 2012;79(5):980–6. https://doi.org/10.1016/j.urology.2011.09.014
10 Douenias R, Rich M, Badlani G, Mazor D, Smith A. Predisposing factors in bladder calculi. Review of 100 cases. Urology. 1991; 37(3):240–3. https://doi.org/10.1016/0090-4295(91)80293-g
11 Zhang D, Li S, Zhang Z, Li N, Yuan X, Jia Z, et al. Urinary stone composition analysis and clinical characterization of 1520 patients in central China. Sci Rep. 2021;11(1):6467. https://doi.org/10.1038/s41598-021-85723-3
12 Moe OW, Abate N, Sakhaee K. Pathophysiology of uric acid nephrolithiasis. Endocrinol Metab Clin North Am. 2002;31(4):895–914. https://doi.org/10.1016/s0889-8529(02)00032-4
13 Kenny JE, Goldfarb DS. Update on the pathophysiology and management of uric acid renal stones. Curr Rheumatol Rep. 2010; 12(2):125–9. https://doi.org/10.1007/s11926-010-0089-y
14 Lieske JC, Rule AD, Krambeck AE, Williams JC, Bergstralh EJ, Mehta RA, et al. Stone composition as a function of age and sex. Clin J Am Soc Nephrol. 2014;9(12):2141–6. https://doi.org/10.2215/CJN.05660614