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Urinary stone composition analysis of 3684 patients in the eastern Shandong region of China

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Abstract

Objective To explore the composition of urinary stones in the eastern Shandong region of China and discuss its clinical significance. Methods A total of 3684 specimens of urinary calculi from the eastern Shandong region were collected in our study. Compositions of stones were analyzed by Automatic Infrared Spectrum Analysis System (type LIIR-20). The results were verified through manual analysis of the spectrogram which is accompanied by polarizing microscopy and chemical analysis if necessary. Results Among the 3684 specimens, there were 1767 single-component stones and 1917 mixed-component stones. According to the difference of the main components of the stones, the stones can be divided into the following types: calcium oxalate monohydrate stones (1779, 48.29%), anhydrous uric acid stones (1105, 29.99%), carbonate apatite stones (590, 16.02%), ammonium magnesium phosphate hexahydrate stones (143, 3.88%), calcium oxalate dehydrate stones (36, 0.98%), and cystine stones (31, 0.84%). Conclusion There are relatively many uric acid stones in the eastern Shandong region of China. The automatic infrared spectrum analysis system for calculus has the advantages of accuracy and convenience.

Background

Urinary calculi are one of the major diseases of urology with the characteristics of high recurrence rate and impaired kidney function [1–3]. The analysis of urinary stones composition is of great significance for the diagnosis, treatment and prevention of calculi in a region. At present, infrared spectroscopy is the standard method for analyzing stone components [4]. It can be used to analyze the crystal composition and non-crystal components of stones with the characteristics of fast detection speed and less required specimens. We collected 1643 stone specimens from April 2015 to March 2019 and analyzed the stone composition by using the infrared spectrum automatic analysis system.

Methods

Clinical data

Our research has been approved by the Ethics Committee of Yantai Yuhuangding Hospital, and we have obtained the informed consent from all patients. And our research has been registered. In our trial, a total of 3684 cases of stone specimens were collected, including the stones discharged by the patients themselves and the stones removed by surgery. There are 2103 males and 1581 females, and the age ranges from 2 to 82 years. The average age of males was 37.32±16.94 years old and the average age of females was 42.34±15.60 years old. There were 2512 (68.19%) patients with kidney stones, 1133 cases (30.75%) with ureteral stones, and 39 cases (1.06%) with bladder stones.

Methods

Compositions of stones were analyzed by Automatic Infrared Spectrum Analysis System (type LIIR–20), and the main components of the stone will be recorded. According to the European Society of Urology guidelines [3], the stone components are divided into the following categories: calcium oxalate monohydrate, anhydrous uric acid, carbonate apatite, ammonium magnesium phosphate hexahydrate, calcium oxalate dehydrates, cysteine, ammonium urate. First, the stones will be washed with water and placed in an oven at 70~ 100℃ for drying. Mixed the stone powder (1 mg) with dry potassium bromide (200 mg), and then ground them in an agate mortar. We baked the mixture for 10 to 30 minutes, took it out and pressed it to make a translucent sheet, which will be quickly placed in the infrared spectrometer for scanning. Finally, the computer drew a spectrum and automatically analyzed the stone composition. The results will be verified through manual analysis of the spectrogram which was accompanied by polarizing microscopy and chemical analysis if necessary.

Results

Among the 3684 specimens, there were 1767 single-component stones and 1917 mixed-component stones. According to the difference of the main components of the stones, the stones can be divided into the following types: calcium oxalate monohydrate stones (1779, 48.29%), anhydrous uric acid stones (1105, 29.99%), carbonate apatite stones (590, 16.02%), ammonium magnesium phosphate hexahydrate stones (143, 3.88%), calcium oxalate dehydrate stones (36, 0.98%), and cystine stones (31, 0.84%). Most of the mixed stones are calcium-containing components, mainly including calcium oxalate stones and carbonate apatite stones (Table 1). The results of our study showed that the calcium oxalate stones have the highest detection rate, followed by uric acid stones, carbonate apatite stones, infectious stones and cystine stones.

Discusion

Schubert et al [5] reported that chemical methods were the main method of stone analysis before 1980s, accounting for 87%, while the infrared spectroscopy and X-ray diffraction methods accounted for only 8% and 5%, respectively. However, infrared spectroscopy has now become the main method for analysis of stone components [6]. Infrared spectroscopy is a method for qualitative and quantitative analysis of substances and determination of molecular structure by using the infrared spectra of samples, which has the advantages of accuracy, fast speed and comprehensiveness.

The results of the infrared spectrum automatic analysis system showed that the calcium oxalate stones have the highest detection rate, followed by uric acid stones, carbonate apatite stones, infectious stones and cystine stones. Among the results, the proportion of calcium oxalate stones is the highest, which is similar to the analysis results in Nanjing, Jilin and Guangdong provinces. However, the detection rate of uric acid stones in the eastern Shandong region area is relatively high, which is quite different from the above areas. Some results showed that diets with high meat intake and low intake of vegetables are more likely to cause uric acid crystallization in the urine and promote the formation of uric acid stones [7]. The reduction in vegetable intake also leads to a decrease in oxalic acid excretion in the urine [8]. So, we hold the opinion that high proportion of uric acid stones may be related to the eating habits of the eastern Shandong region area. Foods such as animal protein and seafood account for a large proportion of daily diet, which contains abundant purines and phosphorus. Moreover, many people have the habit of drinking. However, the specific reasons require further long-term research and analysis.

Similar to the results in other analysis [2, 9], male predominance was also found in our report. The proportion of male patients is higher than that of females, which is related to dietary habits and sex hormone levels [10]. Our report also shows that stones with mixed components are more common than single-component stones. Most of the mixed stones are calcium-containing components, mainly including calcium oxalate and carbonate apatite, and calcium-free stones are relatively rare. The content of calcium oxalate or calcium phosphate in stones is related to metabolic abnormalities. The formation of such stones is affected by many factors. To identify the main causes of stone formation, it is necessary to further improve related examinations and epidemiological statistics.

The results of this study showed that the automatic analysis system of stone infrared spectrum has the advantages of accurate, automatic and fast speed, which has high value and significance for the analysis of the cause of urinary stones. The stone composition of patients in the eastern Shandong region of China has commonality and specialty with other areas. According to the geographical environment of the eastern Shandong region, the eating habits of the residents and the living standard, combined with the analysis of the composition of the stones, the following suggestions and treatments are proposed for the patients. (1) Patients with uric acid stones should appropriately limit the diets containing purine, such as seafood, meat, animal offal, beer, bean products, mushrooms, peas, etc. (2) Patients with calcium oxalate stones should limit high-protein diet and drinking, and try to reduce the edible which high in calcium oxalate, such as spinach, tomatoes, and beans. Eat more fiber-based foods to reduce the saturation of calcium salts, reduce the formation of calcium salts and the formation of stones. (3) Patients with calcium phosphate stones should control urinary tract infections, eat more acidic foods, such as grains, peanuts, eat meat of the grains or peanuts in moderation. (4) Patients with cystine stones should eat more citrus or juice. (5) Mixed stones of various components are simultaneously prevented according to the above recommendations. (6) All patients with urinary stones should develop the habit of drinking more water, ensure that the daily urine volume is above 2000 mL, and regularly undergo imaging examination as well as the related metabolic indicators examination, actively prevent and reduce the recurrence of urinary stones.

Conclusion

There are relatively many uric acid stones in the eastern Shandong region of China. The automatic infrared spectrum analysis system for calculus has the advantages of accuracy and convenience.

Abbreviations

W1: calcium oxalate monohydrate; U: anhydrous uric acid; CH: carbonate apatite; PM: ammonium magnesium phosphate hexahydrate; W2: calcium oxalate dehydrates; CYS: cysteine; UA: ammonium urate.

Declarations

Ethics approval and consent to participate: All patients in our research provided written informed consent before the treatment. All procedures in this research were performed in accordance with the principles of the Research Ethics Committee of the Affiliated Yantai Yuhuangding Hospital of Qingdao University and with the 1964 Helsinki Declaration and its amendments.

Consent for publication: Not applicable.

Availability of data and material: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Authors' contributions: CHL is Corresponding author of the article. XBZ is first author. JJM is Co-first author. CHL designed the research, interpreted the data and revised the paper. XBZ, JJM, and NW performed the data extraction and drafted the paper. All authors read and approved the final manuscript.

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References

1.Mandeville JA, Nelson CP: *Pediatric urolithiasis. Current opinion in urology* 2009, *19(*4):419–423.

2.Novak TE, Lakshmanan Y, Trock BJ, Gearhart JP, Matlaga BR: *Sex prevalence of pediatric kidney stone disease in the United States: an epidemiologic investigation. Urology* 2009, *74(*1):104–107.

3.Skolarikos A, Straub M, Knoll T, Sarica K, Seitz C, Petrik A, Turk C: *Metabolic evaluation and recurrence prevention for urinary stone patients: EAU guidelines. European urology* 2015, *67(*4):750–763.

4.Wignall GR, Cunningham IA, Denstedt JD: *Coherent scatter computed tomography for structural and compositional stone analysis: a prospective comparison with infrared spectroscopy. Journal of endourology* 2009, *23(*3):351–357.

5.Schubert G: *Stone analysis. Urological research* 2006, *34(*2):146–150.

6.He Z, Jing Z, Jing-Cun Z, Chuan-Yi H, Fei G: *Compositional analysis of various layers of upper urinary tract stones by infrared spectroscopy. Experimental and therapeutic medicine* 2017, *14(*4):3165–3169.

7.Siener R, Hesse A: *The effect of a vegetarian and different omnivorous diets on urinary risk factors for uric acid stone formation. European journal of nutrition* 2003, *42(*6):332–337.

8.Holmes RP, Goodman HO, Assimos DG: *Contribution of dietary oxalate to urinary oxalate excretion. Kidney international* 2001, *59(*1):270–276.

9.Dursun I, Poyrazoglu HM, Dusunsel R, Gunduz Z, Gurgoze MK, Demirci D, Kucukaydin M: *Pediatric urolithiasis: an 8-year experience of single centre. International urology and nephrology* 2008, *40(*1):3–9.

10.Croppi E, Ferraro PM, Taddei L, Gambaro G: *Prevalence of renal stones in an Italian urban population: a general practice-based study. Urological research* 2012, *40(*5):517–522.

Table

Table 1 Composition of urinary tract stones in the eastern Shandong region of China

Groups	Cases	Single component	Two components	Three components	Four components
W1	1779	W1: 600	W1/CH: 458		
			W1/W2: 198	W1/W2/CH: 521	
				W1/W2/ PM: 2	
U	1105	U: 930	U/W1: 175		
CH	590	CH: 268	CH/W1: 93	CH/W1/W2: 180	CH/W1/W2/PM: 8
				CH/W1/PM: 14	
			CH/PM: 16		
				CH/W2/W1: 8	CH/W2/W1/PM: 3
PM	143	PM: 88	PM/CH: 24	PM/CH/W1: 10	PM/CH/W1/W2: 11
				PM/CH/W2: 1	PM/CH/ W2/W1: 3
			PM/W1: 1		
				PM/UA/CH: 5	
W2	36	W2: 0	W2/W1: 16	W2/W1/CH: 20	
CYS	31	CYS: 31			

W1: calcium oxalate monohydrate; U: anhydrous uric acid; CH: carbonate apatite; PM: ammonium magnesium phosphate hexahydrate; W2: calcium oxalate dehydrates; CYS: cysteine; UA: ammonium urate.