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TYPES AND COMPOSITION OF URINARY STONES IN 4 COMMUNITY HOSPITALS

ชนิดและองค์ประกอบของก้อนนิ่วในโรงพยาบาลชุมชน 4 แห่ง

Pote Sriboonlue
พจน์ ศรีบุญลือ

Wichai Chaichitwanichakul
วิชัย ชัยจิตวณิชกุล

Kungwal Wongrasameedeun
กังวาล วงศ์รัศมีเดือน

Vitoon Triratawong
วิฑูรย์ ตรีรัตวงศ์

Payak Pariyawongsakul
พยัคฆ์ ปริยวงศ์สกุล

Ittipol Soongkhang
อิทธิพล สูงแข็ง

Vitoon Prasongwatana
วิฑูรย์ ประสงค์วัฒนา

Faculty of Medicine, Khon Kaen University
คณะแพทยศาสตร์ มหาวิทยาลัยขอนแก่น

ABSTRACT

A series of 114 urinary stones collected from 4 community hospitals in Udon Thani Province were analyzed for chemical composition by infrared spectroscopy. These stones were surgically removed from 95 adults (male/female = 2) and 19 children (boy/girl = 3) during the period of 1988-1989. Calcium oxalate was the most frequent component found in adult stones of both upper (96%) and lower (80%) urinary tracts (UUT and LUT). Of the childhood stones, while calcium oxalate was seen in all 5 UUT stones, uric acid/urate was the most common component of stones from LUT (64%). The calculi were classified according to their main components into 4 types; calcium oxalate, calcium phosphate, *magnesium ammonium phosphate and uric acid/urate. The most predominant stone type found in adult UUT and LUT and in childhood UUT was calcium oxalate whereas uric acid/urate was the main type of childhood LUT stones.*

บทคัดย่อ

ทำการวิเคราะห์องค์ประกอบของก้อนนิ่วจากทางเดินปัสสาวะจำนวน 114 ก้อนด้วยวิธี infrared spectroscopy ซึ่งก้อนนิ่วเหล่านี้ได้มาจากการผ่าตัดนิ่วที่โรงพยาบาลชุมชน 4 แห่งของจังหวัดอุดรธานี ระหว่างปี 2531-2532 ประกอบด้วย นิ่วในผู้ใหญ่ 95 ราย (อัตราส่วนชาย/หญิง = 2) และในเด็ก 19 ราย (อัตราส่วนชาย/หญิง = 3) องค์ประกอบที่พบได้บ่อยที่สุดในก้อนนิ่วจากผู้ใหญ่คือแคลเซียมออกซาเลต ซึ่งพบในนิ่วจากทางเดินปัสสาวะส่วนบน (upper urinary tract, UUT) และส่วนล่าง (lower urinary tract, LUT) ร้อยละ 96 และ 80 ตามลำดับ ส่วนก้อนนิ่วจากเด็กนั้นพบแคลเซียมออกซาเลตในนิ่วจาก UUT ทุกก้อน และพบว่า กรดยูริค/ยูเรต เป็นองค์ประกอบที่พบได้บ่อยที่สุด ถึงร้อยละ 64 ในก้อนนิ่วจาก LUT ก้อนนิ่วสามารถแบ่งตามองค์ประกอบหลักได้เป็น 4 ชนิด คือ แคลเซียมออกซาเลต แคลเซียมฟอสเฟต แมกนีเซียมแอมโมเนียมฟอสเฟต และกรดยูริค/ยูเรต นิ่วชนิดที่พบมากที่สุดทั้งใน UUT และ LUT ของผู้ใหญ่ และใน UUT ของเด็ก คือ แคลเซียมออกซาเลต ส่วนใน LUT ของเด็กชนิดที่พบมากที่สุด คือ กรดยูริค/ยูเรต

INTRODUCTION

A number of metabolic and environmental factors have been described as the causes of calculi formation in the urinary tract[23]. One approach to understanding these disorders, from which the patients suffer, is the analysis of chemical composition of the formed stones. Knowledge of urolith chemistry is a prerequisite underlying some effective treatment or measure to prevent recurrence[9, 10]. Numerous physical and chemical techniques have been used for the analysis of stone composition. Among them wet chemical analysis, the oldest technique, is still widely used due to its straight forward protocol and since it does not require expensive specialized equipments[11]. Unfortunately, chemical methods can only determine redicals and ions, and therefore cannot differentiate between similar crystalline entities (e.g. uric acid vs. uric acid dihydrate or apatite vs. brushite or whewellite vs. weddellite). Furthermore, these methods require a relatively large quantity of test materials. Infrared (IR) spectroscopy is a technique for urolith analysis. Although there is a wide divergence of expert opinion on the value of IR spectroscopy for urolith analysis[8, 27], some modern laboratories are now analyzing calculi by the IR spectroscopy rather than by the classical wet chemical technique[8, 18, 27]. The advantages of thc IR spectroscopy are greater speed and specificity, uniform sensitivity to all components, and decreased quantities of test substances[1,5,18,29]. The objective of this paper is to examine the chemical composition of urinary stones by IR spectroscopy.

MATERIALS AND METHODS

Urinary tract stones were collected from patients undergoing surgery in 4 community hospitals namely: Pen, Sang Com, Nam Som and Ban Dung of Udon Thani Province in northeast of Thailand during the period 1988-1989. One hundred and fourteen stones from patients with complete hospital records were analyzed in this study.

Prior to analysis, the stones were washed with distilled water to remove blood and attached tissues and oven-dried at 70°C overnight. These stones were then cut approximately at the middle with a fine saw. The powder resulting from the cutting process was often sufficient for the IR analysis.

IR spectra were obtained using the KBr pellet technique. These were made by mixing the calculi powder of about 1 percent with KBr, grinding together in an Agate mortar and pressing the resulting mixture into disks with a force of 2.36×10^{-7} N. The disks were run on Shimadzu IR spectrophotometer, model IR-460 (Shimadzu Corporation, Spectrophotometric Instruments Plant, Analytical Instruments Division, Kyoto, Japan) which covered the range of 4,000 to 500 cm^{-1}. Various principles of interpreting IR spectra of stones have been suggested[18,29]. In this case, spectra of the unknowns were compared with spectra of the known pure substances as described by Corns[5].

RESULTS

The patients were comprised as follows: 95 adults (16 years old and above; 60 males and 35 females) and 19 children (15 years old and below; 14 boys and 5 girls). The majority of stones found among children were in LUT whereas stones of adults were predominantly located in UUT (Table 1).

Calcium oxalate was the most frequent mineral component found in stones of adults both from UUT (96%) and LUT (80%) as shown in Table 2. In the case of children, although all examined 5 UUT stones contained calcium oxalate, the most common component of LUT stones was uric acid/urate (78%) (Table 3). Second to calcium oxalate was hydroxy apatite, a form of calcium phosphate, which were detected in 70%, 68% and 40% of stones from UUT, and LUT of adults, and UUT of children, respectively. However, carbonate apatite and magnesium ammonium phosphate hexahydrate were observed only in small number of stones from both groups of the subjects. Taking the number of components in stone into account, most of adult stones had a mixture of 2 components: calcium oxalate and hydroxy apatite (Table 4). Stones in children, however, were composed mainly of a single component: calcium oxalate for UUT and uric acid for LUT (Table 5).

Since IR analysis is primarily a qualitative procedure, the peak heights of spectra have only and approximate to concentration[6]. Thus classification of these calculi would differ from those wet chemical methods described by Hodgkinson[12]. In this report the calculi were divided into 4 types according to their main components: calcium oxalate, calcium phosphate, magnesium ammonium phosphate and uric acid/ urate. The results showed that calcium oxalate stones were the predominant type in both UUT (76%) and LUT (64%) of adults (Table 4). This was also the case for childhood UUT stones (80%) as shown in Table 5. Stone from childhood LUT, however, the most common type was uric acid/urate (64%). The second most abundant type of stones was calcium phosphate which was found common to both locations of the adult urinary tracts. In the case of magnesium ammonium phosphate stone, this could be regarded as a minor stone type observed in this study, since only a few of them were presented. Cystine and brushite were not detected in any stone studied.

DISCUSSION

Knowledge of the chemical nature of the stone is an important guide to success in management of the disease[9,10]. Information on chemical analysis of stones from patients in the northeast region of Thailand is still limited and not up to date. Sakornmonkol *et al.*[24] presented the first qualitative wet chemical method in an analysis of stones from Ubon Ratchathani provincial hospital in 1962 and by means of optical crystallography, X-ray diffraction photography and Geiger Muller counter X-ray diffractometer, Gershoff *et al.*[7] reported the analysis of stone collected from Khon Kaen provincial hospital in 1963. More update data were studied by Prasongwatana and co-workers[20] using the conventional wet chemical method. IR spectroscopy has been claimed to have more advantages in many aspects over the wet chemical method in analysis of stone compositions[1,5,18,29]. The technique needs only a small amount of test sample, the result is more uniformly sensitive to all components and has greater reproducibility. All in all, it permits a positive identification of most of the components present in analyzed calculi.

Data from many epidemiological studies[2,22,25] suggest that the pattern of urinary tract stone disease in this region now had changed, with a steadily increasing prevalence of UUT stones, as is the case in many industrialized countries[13,15]. Since all of these studies were carried out in central or provincial hospitals, one might argue that this change of stone pattern is probably due to the referral system which is usually in the direction of community to provincial hospitals. The present data from 4 community hospitals clearly showed that, for adults, the stones from UUT were three times more prevalence than for LUT (Table 1). This finding was similar to that reported by Raiyawa and co-workers[22] who also studied urinary stone disease in a nearby community hospital. Chutikorn and associates[4] reported experiences at Ubon Ratchathani provincial hospital during the period of 1956-1962. Regarding the children with calculi, about 91 percent had LUT stone. This study found that as much as one-third of childhood stones were from UUT (Table 1). Thus the childhood stone pattern seemed to change in the same manner as that of adult's. This finding was similar to those observed in northern Thailand[3].

In this study, data on the composition of childhood stones demonstrated that uric acid/urate was the major component of the stones from UUT and that they existed more commonly in pure state (Table 5). The finding confirmed previous studies by others although different techniques were employed[7,15,20]. High prevalence of uric acid/urate stone in childhood was a unique feature of endemic bladder stone in the Middle and the Far East. The stone was once also common in Britain during the late 18th and early 19th century and then disappeared during the World War I[15]. The disappearance of the disease is said to be due to a variety of factors but mainly to the improvement of nutrition, with increased dietary phosphate and protein intake[15,28]. These findings suggest that the problem of an unbalanced diet as a cause of LUT stones, similar to the past in the area studied, still existed. Taking childhood UUT stones into account, calcium oxalate was the main component and the most frequent type of stone found. This composition is, in fact, comparable to that of adult UUT stones suggesting that factors underlying stone formation are probably similar to UUT stones of both adults and children.

The chemical composition of adult stones resembled data obtained from Ubon Ratchathani[15] and Khon Kaen Provinces[7,20]. Adult stones consisted mainly of calcium oxalate mixed with a variable amount of calcium phosphate in the form of hydroxy apatite (Table 4). Furthermore, stones containing calcium oxalate were the most common single component stones found in this investigation. The results were also similar to reports from elsewhere[16,21]. Magnesium ammonium phosphate hexahydrate and carbonate apatite calculi are reported to occur only in the presence of infection[9]. These types of stone found less frequently than as reported by Prasongwatana and co-workers[20]. Since this study is not a case selection, the lower prevalence of infective stones should be partly due to a less sensitivity of IR spectroscopy technique in determining of these 2 components[5,6,18,19].

The presence of calcium phosphate stone, mainly hydroxy apatite but often with some calcium oxalate would suggest renal tubular acidosis or hyperparathyroidism[14]. Study of blood and urine biochemistry of renal stoneformers, Sriboonlue and co-workers[26] have shown that hyperparathyroidism was very unlikely to be a contributing factor for the formation of this stone type. On the other hand, distal renal tubular acidosis was reported to be endemic in northeast Thailand[17]. These data showed that most calcium phosphate calculi of adults had hydroxyapatite as the main component and were always mixed with calcium oxalate (Table 4). Since the indication of infection in adult urinary tract (the presence of carbonate apatite and magnesium ammonium phosphate haxahydrate as the outcomes of infection) was rare, the association of calcium phosphate stones with renal tubular acidosis was very likely. This study suggests that this relationship should have been further investigated in order to achieve a better understanding of the disease. Furthermore, these data suggest that stones composed of cystine and brushite are not the health problem of people in the northeast. Similar observations have also been made by Gershoff and co-workers[7] and Prasongwatana and co-workers[20].

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Table 1. Demographic data

Descriptions	Adults	Children
Number of patients	95	19
Age in years (X ± SD)	40.8 ± 15.2	7.7 ± 3.6
Male : female	60:35	14:5
Upper urinary tract stones	70(73%)	5(26%)
Lower urinary tract stones	25(27%)	14(74%)

Table 2. Number of adult stones containing each chemical component

Chemical names	No. of stones	
	UUT (n=70)	LUT (n=25)
Calcium oxalate	67 (96%)	20 (80%)
Hydroxy apatite	48 (70%)	17 (68%)
Carbonate apatite	1 (1%)	1 (4%)
Magnesium ammonium phosphate hexahydrate	2 (3%)	-
Uric acid/Urate	5 (7%)	4 (16%)

Table 3. Number of childhood stones containing each chemical component

Chemical names	No. of stones	
	UUT (n=5)	LUT (n=14)
Calcium oxalate	5 (100%)	4 (80%)
Hydroxy apatite	2 (40%)	-
Carbonate apatite	-	-
Magnesium ammonium phosphate hexahydrate	-	2 (14%)
Uric acid/Urate	1 (20%)	11 (78%)

Table 4. Types of adult stone classified by main components

Stone types	Location of stones	
	UUT (n=70)	LUT (n=25)
Calcium oxalate (CaOx), total	53 (76%)	16 (64%)
CaOx only	15	3
CaOx+ HAp*	34	13
CaOx+ U	2	-
CaOx+ HAp + U	2	-
Calcium phosphate (Cap), total	13 (18%)	5 (20%)
HAp + CaOx	12	4
CAp**	-	1
CAp + CaOx	1	-
Magnesium ammonium phosphate hexahydrate (MAP)	2 (3%)	-
Uric acid/Urate (U), total	2 (3%)	4 (16%)
U	-	3
U + CaOx	2	1

*HAp = hydroxy apatite
**CAp = carbonate apatite

Table 5. Types of childhood stone classified by main components

Stone types	Location of stones	
	UUT (n=5)	LUT (n=14)
Calcium oxalate (CaOx), total	4 (80%)	4 (29%)
CaOx only	2	2
CaOx+ HAp*	1	-
CaOx+ U	1	2
Calcium phosphate (Cap), total	1 (20%)	-
HAp + CaOx	1	-
Magnesium ammonium phosphate (MAP)	-	1 (7%)
Uric acid/Urate (U), total	-	9 (64%)
U	-	8
U + MAP	-	1

*HAp = hydroxy apatite