

CHEMICAL COMPOSITION OF URINARY CALCULI FROM AL-JOUF PROVINCE OF SAUDI ARABIA

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ABSTRACT

Objective: Saudi Arabia has a high incidence of urolithiasis. This study was undertaken to understand the composition and location of the stones from patients living in the province of Al-Jouf of Saudi Arabia.

Methods: Fifty-eight renal calculi from Al-Jouf area of Saudi Arabia were analyzed by semiquantitative titrimetric and colorimetric methods.

Results: The urinary stones were mainly localized in the bladder (36.3%) followed by the kidneys (27.6%) and were more frequent in males (88%). The result of the analysis shows that the calculi belong to oxalate (84.5%), calcium (65.5%), magnesium (58.6%), urate (36.2%), phosphate (27.6%), carbonate (13.8%), ammonium (6.9%) and cystine (1.7%). The most frequent chemical constituent was calcium oxalate (48.3%) followed by ammonium urate (22.4%), calcium phosphate (15.5%) and magnesium phosphate (13.8%) and pure form of uric acid (13.8%). Oxalate containing stones were more frequent in males than in females while phosphates containing ones were less frequent in males than in females.

Conclusion: The findings of the present work indicate that urolithiasis in the province of Al-Jouf represent common urological problem and is correlated with the nutritional, environmental and genetic factors.

Key words: Urinary calculi, Uric acid, Ammonium, Calcium Oxalate, Phosphate, Cystine, Saudi Arabia.

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Introduction

Urinary calculi have afflicted humankind since antiquity. Scientists have found evidence of kidney stones in an Egyptian mummy more than 7000 years old.⁽¹⁾ These stones are more common in some parts of the world including Saudi Arabia.^(1,2) The risk of urolithiasis shows different frequencies: 1-5% in Asia, 5-9% in Europe, 13% in North America and 20% in Saudi Arabia.⁽³⁻⁶⁾ One in five of all patients attending the urologic clinics of King Abdulaziz University Hospital, Jeddah had urinary calculi.⁽¹⁾

Epidemiological studies show that renal stone formation is a complex multifactorial disease associated with dietary habits, life-style, socio-economic status, environmental and genetic factors.^(7,8) The majority of the reports showed no

evidence of any rise in the risk of stone formation in relation to tap water hardness.

The chemical composition and location of the urinary calculi differ in various parts of the world and change over time due to environmental, nutritional and genetic factors.^(5,7,9) Chemical analysis gives important evidences for the origin, etiology and the metabolic basis of stone formation. Accordingly, this investigation was done to characterize the chemical composition of renal stones from Al-Jouf province of Saudi Arabia.

Methods

Fifty-eight urinary calculi belonging to Saudi (n=46) and non-Saudi (n=12) patients resident in Al-Jouf province of Saudi Arabia were used for chemical analysis. These stones were either removed

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surgically or were expelled by urination during the period January 2004 to January 2005. The sample represented six nationalities (Saudi, Egyptian, Bengali, Sri Lankan, Syrian and Pakistani) that were resident in Al-Jouf area for three years or more.

Analyses have been carried out at the central laboratory of Prince Abdel-Rahman Al-Sudary Hospital, Skaka-Al-Jouf and at the research laboratories of the Department of Medical Laboratory Sciences, Al-Jouf University. The stones were powdered in a mortar and were analyzed chemically by semiquantitative titrimetric and colorimetric methods by using two different kits supplied by Semmelweis Co., Maascia Bruneli division (Italy) and Lancer, Sherwood Medical Co. (Ireland) respectively. Both powdered stones and the standards were analyzed for carbonate, oxalate, phosphate, uric acid, ammonium, magnesium, calcium and cystine contents. Organic and inorganic nature of the renal stones was identified by flame and burning tests.⁽¹⁰⁾

Results

Out of 58 renal stones, 51 (88%) stones belonged to males while 7(12%) belonged to females giving a male to female ratio of 7.3:1. The age of the patients ranged from three to 56 years while 36(62.1%) of the patients were in their third decade of life (Table I & Fig. 1).

Table I. Distribution of calculi according to age

Group age (years)	Number of stones	Percentage
Less than 20	1	1.7
20-29	7	12.1
30-39	36	62.1
40-49	13	22.4
50-59	1	1.7
Above 60	0	0.0

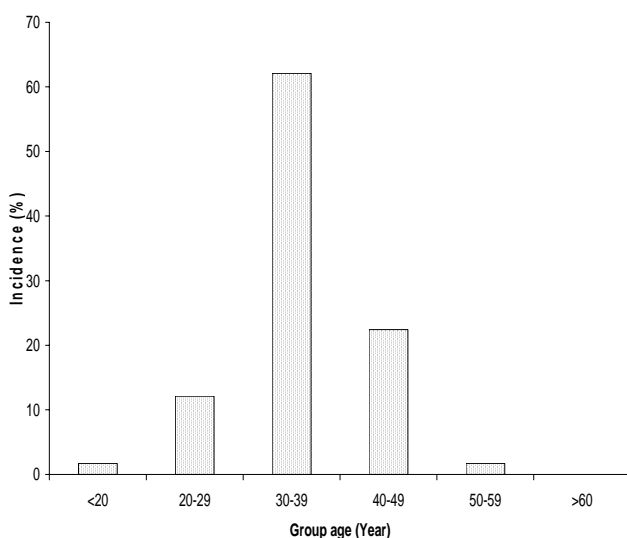


Fig. 1. Distribution of calculi according to age

Calculi were mainly localized in the bladder (36.2%) followed by kidneys (27.6%), and ureters (25.9%) while 10.3% were passed calculi (Table II & Fig. 2). The ratio of right kidney to left kidney stones was 5:3 with no bilateral kidney nephrolithiasis.

Table II. Distribution of calculi according to location

Location	Number of Stones	Percentage
Right kidney	10	17.2
Left Kidney	6	10.4
Ureters	15	25.9
Urinary bladder	21	36.2
Urethral	0	0.0
Expelled calculi	6	10.3

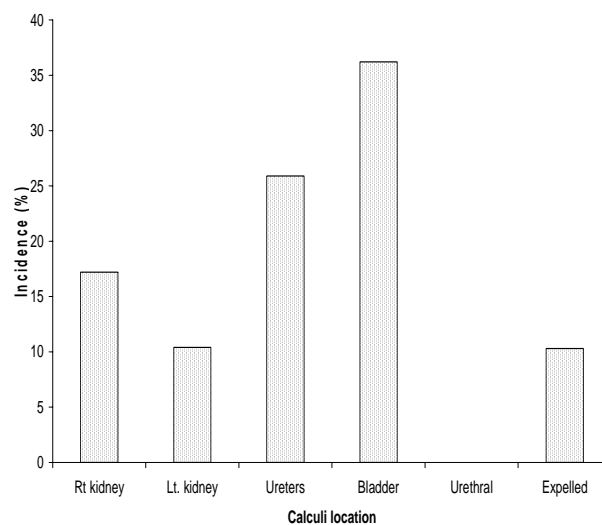


Fig. 2. Distribution of calculi according to location

The result of the analysis revealed that (15.5%) of the calculi were pure stones while (84.5%) were mixed ones. The pure forms of calculi were uric acid and cystine. As shown in Table III and Fig. 3, the investigated calculi belonged to the chemical groups: Oxalate (84.5%), calcium (65.5%), magnesium (58.6%), uric acid (36.2%), phosphate (27.6%), carbonate (13.8%), ammonium (6.9%) and cystine (1.7%).

Table III. Distribution of stones according to the chemical groups*

Type of stone	Number of stones	Percentage
Oxalate calculi	49	84.5
Calcium calculi	38	65.5
Magnesium calculi	34	58.6
Uric acid calculi	21	36.2
Phosphate calculi	16	27.6
Carbonate calculi	8	13.8
Ammonium calculi	4	6.9
Cystine calculi	1	1.7

*Total do not add to 100%

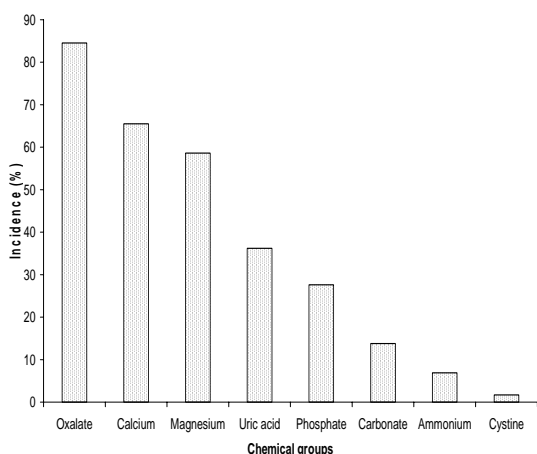


Fig. 3. Distribution of stones according to the chemical groups

Calcium oxalate was the commonest constituent (48.3%) followed by ammonium urate (22.4%), calcium phosphate (15.5%), magnesium phosphate (13.8%), pure form of uric acid (13.8%), calcium magnesium phosphate (10.3%), calcium carbonate (8.6%), magnesium ammonium phosphate (3.4%), and cystine (1.7%) in that order (Table IV & Fig. 4).

Table IV. Chemical constituents of the urinary stones

Type of stones	Number of stones	Percentage
Calcium oxalate	28	48.3
Ammonium urate	13	22.4
Calcium phosphate	9	15.5
Uric acid (pure form)	8	13.8
Magnesium phosphate	8	13.8
Calcium magnesium phosphate	6	10.3
Calcium carbonate	5	8.6
Magnesium ammonium phosphate	2	3.4
Cystine (pure form)	1	1.7

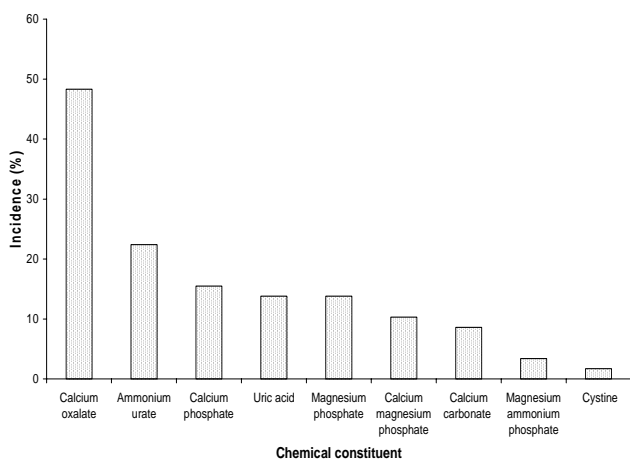


Fig. 4. Incidence of the chemical constituents of the urinary stones

Discussion

Renal stones represent major urological problem in all parts of the world including Saudi Arabia.^(1,2,11) About 12% of the population of the European Union suffers at least one process related to urolithiasis with variable frequency as shown with the epidemiological studies such as Italy (13%), Sweden (8.9%) and Spain (12.3%).^(5,12)

Urinary stones incidence is higher in countries with warm or hot climates. Exposure to sunlight and seasonal variation may enhance calcium absorption and urinary excretion, which leads to stone formation.^(13,14) An increase of stone formation was noticed among American army personnel deployed in Kuwait from March through August 2003.⁽¹⁵⁾ Reports from different parts of the world indicate that geographical variations in the incidence of urinary calculi are correlated with socio-economic conditions.⁽¹¹⁾ Obesity, calculi family history together with high protein, fat, energy and vitamins intake is also risk factors.^(5,9,16-19) No evidence of stone formation risk was found in relation to drinking tap water.^(5,17)

The population of Al-Jouf Province is about 361,000 where Saudi to non-Saudi ratio is about 6:1. The present study shows that males of this province are more affected with urolithiasis than females with a ratio of 7.3:1. This ratio is higher than those recorded in other provinces of Saudi Arabia.^(1,11,20,21) The male predominance may be related to the climate conditions and life-style in Saudi Arabia where women, in contrary to men, spend most time indoors with their families. Chronic exposure to hot environment and massive sweating with subsequent dehydration and urine concentration increase the prevalence of urolithiasis. Reports from other countries indicated that males are more affected than females such as Libya 2.5:1, Algeria, 4:1, Sweden, 3:1 and United Kingdom, 2.7:1.⁽²²⁾ Some studies ascribed the high prevalence of nephrolithiasis in males to the effect of sex hormones on some lithogenic risk factors where androgens appear to increase and estrogen to decrease urinary oxalate excretion and kidney calcium oxalate deposition.^(5,23)

The present work shows urolithiasis in Al-Jouf Province develops more frequently in the age group of the third decade of life. This result is in agreement with other studies from Saudi Arabia where the peak age of presentation is 22-44 years.^(1,21,24-27) The urolithiasis peak age in Al-Jouf province is similar to those of Sudan,⁽²⁸⁾ Jordan⁽²⁹⁾ and Southern Iraq.⁽³⁰⁾

The results also show that the urinary stones in Al-Jouf province are mainly localized in the bladder. In the last three decades, bladder stone has almost disappeared in the Western countries where it is presently mainly restricted to elderly men with

prostatic obstruction. Bladder stones are related to poor socio-economic conditions⁽⁵⁾ and still predominate in the developing countries including Saudi Arabia.^(1,31-34) For instance, the bladder stones dropped from 30% in 1965 to 5% in 1985 in India⁽³⁵⁾ and from 50% in 1950 to 5% 1985 in Japan⁽³⁶⁾ as a result of improved socio-economic conditions. Bladder stones are also associated with prostatic hyperplasia, neurogenic bladder and cancer.⁽³⁷⁾

In the industrialized countries both sides of the urinary tract are affected equally and about 40% of the patients have bilateral calculi. In the present investigations the right kidney was more affected than the left one with the ratio of 3:2 and bilateral kidney calculi were not seen. Bilateral stones have been reported from other regions of Saudi Arabia.⁽³⁸⁾ Kidney stones are associated with family history, stressful life and genetic factors as seen in cystinuria and tubular acidosis.⁽⁹⁾

Most of the investigated calculi contained calcium mainly in the form calcium oxalate followed by calcium phosphate, calcium magnesium phosphate and calcium carbonate in this order. Calcium oxalate stones were also reported to be the most frequent in other regions of Saudi Arabia⁽²⁷⁾ and as seen by similar works in other countries, with 66.7% in Sudan⁽³⁹⁾, 90.4% of the upper urinary tract stones and 65% of the bladder stones in Norway,⁽¹²⁾ 70.5% in Algeria⁽⁴⁰⁾ and 75.4% in Albania.⁽⁶⁾ Calcium stones occur with hypercaliuria as a potential side effect of high dietary calcium, hyperparathyroidism and calcium supplement.

The present investigation further reveals high prevalence of oxalate calculi in males than in females. This may be due to the fact that androgens increase while estrogens decrease urinary oxalate excretion and kidney calcium oxalate deposition.⁽⁴¹⁾ Oxalate calculi could result from too much oxalate in the diet and likely to occur in people having tubular epithelial injury and those suffer a lack of urinary inhibitors of crystal formation.

The results also show that phosphate stones predominated in women. Infection of the urinary tract, which is more common in women, plays an important role in phosphate stone formation. The struvite calculi (made of magnesium ammonium phosphate mixed with mucopolysaccharide matrix) were observed in 3.4% of the investigated stones. These stones have high potential life-threatening complications and formed as a consequence of urinary tract infection caused by certain types of bacteria specially urea-splitting ones.^(22,42) The incidence of these stones was 3% in Riyadh province,⁽²⁷⁾ 7% Sudan,⁽³⁹⁾ 1.6% in Japan,⁽⁴³⁾ 10.3% in Albania⁽⁶⁾ and 24.6% of the pediatric urolithiasis in Algeria.⁽⁴⁰⁾ Struvite stones occur in patients with

chronic urinary tract infection and are also known as infection calculi.

Uric acid stones frequency in Al-Jouf province as seen in the present study is higher than those reported in Riyadh area (19%),⁽²⁷⁾ Sudan (13.2%), Japan (2.9%), Albania (12.5%).^(6,39,43) Uric acid calculi are diet related and develop with increased urine acidity which crystallizes undissociated uric acid. The Saudi diet including that of Al-Jouf Province is over rich in animal proteins.^(2,17)

Ammonium calculi incidence in Al-Jouf province as is shown in the present investigation is lower than that seen in similar studies: 32.9% in Sudanese children,⁽³⁹⁾ 29.5% in Algeria,⁽⁴⁰⁾ and 7.2% in Albania.⁽⁶⁾ Ammonium urate predominated in the chemical components of the bladder stone in the 20th century.^(1,6) The possible etiologic factors related to these calculi are those that increase the urinary ammonium concentration.

The frequency of cystine calculi in Al-Jouf province is in line with most incidences from other regions of Saudi Arabia and some countries such as Sudan and Albania.^(6,39) Cystine calculi are diagnostic of cystinuria, a hereditary condition in which the kidneys do not reabsorb this amino acid which is insoluble and precipitate when the urinary pH value becomes lower than 6.0.⁽¹⁰⁾

More work is needed to understand the pathogenesis of urolithiasis in Al-Jouf province and other parts of Saudi Arabia.

Limitation of the Study

The size distribution of the calculi can not be done because a considerable number of the patients of Al-Jouf province attend the urologic clinics in Riyadh and Jordan for better facilities.

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