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ORIGINAL RESEARCH

Elemental profile of urolithiasis at a tertiary hospital: a four-year retrospective study

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Background: Urolithiasis is a fairly common disease presenting to urology clinics worldwide. It affects all age groups and genders and is estimated to have a prevalence of between 4% and 20%, depending on the geographical location and socioeconomic context. The peak age for urolithiasis, as reported by some studies, is between 30 and 50 years with a male preponderance. Commonly identified chemical substances include calcium oxalate, calcium phosphate, uric acid, cystine, and triple phosphate. An understanding of the chemical composition of urinary stones in a particular locality will influence the recommendations for the prevention and treatment of these stones.

Objective: To evaluate the elemental profile (chemical composition) of urinary calculi and the sociodemographic characteristics of patients with urinary calculi seeking care at the Tamale Teaching Hospital.

Materials and methods: This was a retrospective study to analyse urinary stones retrieved from patients from 1 January 2016 to 31 December 2019. Data was entered into Microsoft Excel 2016, edited to exclude errors and reorganised for efficient analysis. Data analysis was done using Statistical Package for the Social Sciences (SPSS) version 23 and logistic regression was used to determine the factors significant for stone formation. A p-value < 0.05 was considered statistically significant.

Results: Calcium-containing stones form the majority of urinary stones (56.2%), followed by ammonium urate (12.3%), and uric acid (11.1%). Magnesium ammonium phosphate, xanthine, and cystine constituted two (1.2%) each. Other constituents of the urinary stones, mainly proteins, made up 16.7%. A majority of the patients were from the upper-east (42%) and northern regions (40%). Males were the majority of our patients (92.7%).

Conclusion: Calcium-containing stones are the most common urinary stones in northern Ghana. We recommend adequate fluid intake in northern Ghana, especially the north-eastern part, to cope with the hot climatic conditions.

Keywords: urolithiasis, elemental profile

Introduction

Urolithiasis is a fairly common disease presenting to urology clinics worldwide. It affects all age groups and genders and is estimated to have a prevalence of between 4% and 20%, depending on geographical location and socioeconomic conditions.[1] Despite this, the prevalence is rising globally across all races, ages, and genders.[1] In literature, the current peak age is between 30 and 50 years with a male preponderance.[1-3]

Urolithiasis is formed by the aggregation of chemical substances such as calcium oxalate and uric acid, which are normally excreted in the urine, especially when the urine becomes supersaturated with these substances.[2] Predisposing or risk factors include living in hot climatic areas, high dietary calcium intake, type 2 diabetes, and drugs such as indinavir.[2] The stones formed are found anywhere within the urinary system, i.e. kidney, ureters, bladder, and urethra.[2]

There may be variations in the type of stone identified in a particular locality depending on the geography, lifestyle, and associated metabolic disease of the population.[3] Therefore, an understanding of these variations may influence the recommendations for the prevention and treatment of urinary tract stones. The elemental compositions of urinary calculi commonly identified include calcium oxalate, calcium phosphate, uric acid, cystine, and triple phosphate.[3]

Overall, the composition of urolithiasis shows a leading trend for calcium-containing stones, which accounts for a third of all stone compositions in most studies.[4-7] However, there are variations in the percentages of uric acid, triple phosphate, and cystine as elemental components in the analysed urinary stones.[4-7] In the West African sub-region, some Nigerian authors revealed that calcium-containing stones constituted 76.9% of urinary stones analysed among 49 patients. Uric acid stones were 16.3%, with the remaining being struvite, xanthine, and cystine-containing stones.[8] A report from southern Ghana revealed that about 86% of stones extracted from the upper urinary tract were calcium oxalate, 10% were magnesium ammonium phosphate stones, and 4% were uric acid stones.[9]

The elemental profile of urinary tract stones among patients in northern Ghana is yet to be established. We do not know if the elemental profiles of urinary calculi among the inhabitants of northern Ghana, located in the savannah belt with its attendant hot climate, are different from those of the south, which is predominantly rainforest. Consequently, we set out to review the records to reach an understanding of the chemical compositions of urinary tract stones retrieved from patients who sought care at our centre located in Tamale, in northern Ghana. Data obtained may influence public health policies on the prevention of stone diseases and change practices on treatment strategies.

Materials and methods

Study site and design

The Urology Unit at the Tamale Teaching Hospital serves as a referral centre for urological patients in the entire five regions of northern Ghana. The unit runs a general urology practice and manages patients of all ages and genders with urological conditions. This was a retrospective study conducted from 1 January 2016 to 31 December 2019. Ethical clearance was obtained from the Kwame Nkrumah University of Science and Technology Institutional Review Board with the number CHRPE/AP/566/22.

Characteristics of study participants

We reviewed the records of all patients diagnosed with urinary calculi who had surgical extraction of the calculi. We collected data on age, gender, and address. Also included in the data was the location/site of the stone in the urinary tract, the type of surgery, and the chemical composition of the extracted stone. All stones were analysed by a private laboratory, MDS-Lancet Laboratories Ghana Limited, which used Fourier-transform infrared (FTIR) spectroscopy with a direct transmission technique for stone analysis. We excluded patients who had medical expulsive therapy instituted as an option. Patients whose calculi could not be analysed because of financial constraints or missing specimens were also excluded from the study.

Statistical analysis

Data was entered into Microsoft Excel 2016, edited to exclude errors and reorganised for efficient analysis. Frequencies and proportions were computed using SPSS version 23. Univariate logistic regression was examined to determine the independent risk factors significant for stone formation. The factors included in the regression analysis were age, gender, and geographical location. Age was reclassified into two groups, < 18 years and ≥ 18 years, and a chi-square test was used to compare the association between categorical variables. A p-value < 0.05 was considered statistically significant.

Results

A total of 55 records were retrieved. Of these, 29 (52.7%) were adults and 26 (47.3%) were children. The median age was 21 years with an interquartile range (IQR) of 3.5–53.5 years. There were 51 (92.7%) males and four (7.3%) females. Concerning the geographical location, about 42% (23) of patients lived in the Upper East region. The remaining proportion was from the following regions: 22 (40%) Northern, four (7.3%) North East, three (5.5%) Savannah, and three (5.5%) Upper West (Table I).

Lower urinary tract stones were common in 42 (76.4%) subjects and stones were retrieved surgically. Bladder calculi constituted 40 (72.7%). Urethral stones, however, were the least seen in two (3.6%) subjects. Among the 26 children in this study, there were two (7.7%) urethral, 22 (84.7%) bladder, one (3.8%) ureteric, and one (3.8%) renal pelvic stone. The pattern of distribution was similar for the 29 adults with 18 (62.1%) bladder, two (6.9%) ureteric, and nine (31.0%) renal calculi. The median weight of the stones retrieved among the subjects was 3.2 g, IQR 2.3–4.8 g (Table II).

Table I: Overall demographical characteristics of subjects

Variable	Frequency (%) n = 55
Gender	
Male	51 (92.7)
Female	4 (7.3)
Geographical location	
Upper East region	23 (41.8)
Northern region	22 (40.0)
North East region	4 (7.3)
Savannah region	3 (5.5)
Upper West region	3 (5.5)

Table II: Overall Location of urinary stones

Classification	Frequency (%) n = 55	Mean weight (g)
Location (1)		
Bladder	40 (72.7)	15.6
Renal	10 (18.2)	4.7
Ureter	3 (5.5)	1.9
Urethral	2 (3.6)	1.0
Location (2)		
Upper urinary tract	13 (23.6)	3.8
Lower urinary tract	42 (76.4)	14.9

The chemical analysis carried out on all stones to determine their elemental composition revealed that each stone contained multiple elements. Calcium was the most common element found in all stones (n = 91, 56.2%), followed by ammonium urate (n = 20, 12.3%), and uric acid (n = 18, 11.1%), in descending order. Magnesium ammonium phosphate, xanthine, and cystine constituted two (1.2%) each. Other constituents of stones were mainly proteins (n = 27, 16.7%) (Table III).

Table III: Overall elemental composition of stones

Stone composition	Frequency (%) n = 162
Calcium-containing stones	91 (56.2)
Uric acid	18 (11.1)
Ammonium urate	20 (12.3)
Magnesium ammonium phosphate	2 (1.2)
Xanthine	2 (1.2)
Cystine	2 (1.2)
Others (mainly proteins)	27 (16.7)

To predict factors that make calcium the element in the diagnosis of urinary calculi, a simple linear regression found that, compared to females, males had 29% increased odds of having calcium as a major elemental component in urinary tract stones compared to other elements (odds ratio [OR] 1.29, confidence interval [CI]: 0.12–13.38) (Table IV). Also, patients who were ≥ 18 years old had about 88% decreased odds of having calcium as the major element in urinary calculi (OR 0.12, CI: 0.29–0.50) and this was significant (p = 0.003).

Table IV: Univariate logistic regression of factors that could influence stone formation

Variable	Major stone composition		OR	*p*-value	CI
	Calcium	Others			
Sex					
Female	2 (66.67)	1 (33.33)	1		
Male	36 (70.59)	15 (29.41)	1.29	0.833	0.12–13.38
Age group					
< 18	13 (50.00)	13 (50.00)	1		
≥ 18	25 (89.29)	3 (10.71)	0.12	0.003	0.29–0.50
Region of residents					
Northern	16 (72.73)	6 (27.27)	1		
North East	4 (100)	0 (0.00)	1		
Savannah	1 (33.33)	2 (66.67)	5.33	0.203	0.41–70.20
Upper East	15 (63.64)	8 (36.36)	1.52	0.518	0.42–5.47
Upper West	3 (100)	0 (0.00)	1		

CI – confidence interval, OR – odds ratio

Based on the region of origin, patients from the Savannah region of Ghana had over five times increased odds of having calcium as the major element in urinary calculi (OR 5.33, CI: 0.41–70.20). Also, patients from the Upper East region had about 52% increased odds of having calcium as the major element in urinary calculi (OR 5.33, CI: 0.41–70.20).

Discussion

Calcium-containing calculi constituted more than half (56.2%) of the chemical composition of the calculi found among our study participants. Our finding was consistent with what others have noted.[5,6,8,9] However, in the southern part of Ghana, Klufio and colleagues found that calcium stones constituted a larger proportion (86%) of the calculi extracted from the upper urinary tract of their patients in Accra.[9] This disparity in percentages of calcium-containing stones may have been due to the higher proportion of lower urinary tract stones (76.4%) in our study, which may consist of magnesium ammonium phosphate in about 50.0% of patients.[10]

Based on regional distribution, the Upper East region had the highest number of people presenting with urolithiasis (41.8%). Also, these patients from the Upper East had 52% increased odds of having calcium as the major element in their urinary calculi. This region is in the far north of Ghana and closer to the Sahara desert with a hot climate, predisposing to stone formation. Perhaps, in addition to the hot climatic conditions in this area, there is also a high concentration of calcium contained in the soil or water, which may require further evaluation.

Our study participants who were ≥ 18 years old had 88% decreased odds of having calcium as the major element in urinary calculi. Some studies found that about 40–50% of children with urolithiasis have a metabolic cause.[11-13] In one of these studies, as much as 57% of children with urolithiasis had hypercalciuria.[13] Adults are more likely to develop stone disease from urine stasis and infection due to urinary tract obstruction. As a result, the prevalence of other compositions of stones other than calcium may be higher.

In general, males are more likely to develop urolithiasis compared to females with a ratio of 2–5 : 1 in most studies.[3,6,11,12] We found a much higher ratio of males to females with 13 : 1. This finding is similar to another study in the West African subregion (Nigeria), where researchers reported a male-to-female ratio of 12 : 1.[8] Males are more prone to lower urinary tract obstruction from conditions such as prostatic diseases and urethral stricture in adults, as well as posterior urethral valve and meatal stenosis in children. When these conditions are not treated timeously, there is a resultant stasis of urine and a predisposition to stone formation, perhaps accounting for the higher proportion of stones in males. In addition to this higher proportion, the males in our study had 29% increased odds of having calcium as a major elemental component in urinary tract stones compared with other elements.

In this series we found that lower urinary tract stones were more common (76.4%) with a majority (72.7%) being bladder stones; different from what was found in Nigeria and in Accra, Ghana, where upper tract calculi formed a greater proportion of the calculi retrieved.[14,15] The smaller proportion of upper tract calculi among our participants during the study period could be due to our limited resources in managing upper tract calculi. Consequently, some patients may have preferred other centres, which are better equipped for endoscopic management of calculi. In addition, those patients with upper tract calculi who had medical treatment aimed at the disintegration of calculi had no samples for analysis and were excluded.

Limitations

This retrospective review was associated with limitations. The results obtained cannot be generalised for the entire population of Ghana because the study was conducted at a single centre in northern Ghana, which served as a referral centre for five regions. Some risk factors, such as a lifestyle with high dietary calcium intake, type 2 diabetes, and HIV status requiring drugs such as indinavir, were not established from the records.

Recommendation

We recommend adequate fluid intake in northern Ghana, especially the north-eastern part, to cope with the hot climatic conditions. Again, further research should be conducted to evaluate additional reasons for the high stone burden in the Upper East and Northern regions of Ghana.

Conclusion

Calcium-containing stones are the most common elemental composition of urinary stones in the northern part of Ghana. The Upper East and Northern regions have the highest stone burden in northern Ghana.

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Conflict of interest

The authors declare no conflict of interest.

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Ethical approval

The study protocols were submitted to the Kwame Nkrumah University of Science and Technology Institutional Review Board for review. Ethical approval for the study was obtained from this institution after review with the number CHRPE/AP/566/22.

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