Journal of Renal and Hepatic Disorders

CODON PUBLICATIONS

ORIGINAL ARTICLE: NEPHROLOGY

Differences in Urinary Calculi Characteristics among the Three Main Racial Groups in KwaZulu-Natal, South Africa

Dhesigan Naidoo, Vishan Ramloutan

Department of Urology, Nelson R. Mandela School of Medicine, University of KwaZulu-Natal, Durban, South Africa

Abstract

Racial differences in the characteristics of urinary calculi are poorly described in the South African context, limiting our local understanding of urolithiasis pathology and thwarting our efforts in designing appropriate preventative interventions. We sought to investigate differences in urinary calculi characteristics among the main racial groups in KwaZulu-Natal, South Africa. We conducted a retrospective chart review of patients with urinary calculi at a quaternary hospital in KwaZulu-Natal, South Africa, during 2018–2019. We collected data on the patient's age, sex, race (Caucasian, Asian, Black African), residence, and pre-stenting. Five study outcomes were investigated across racial groups: number of calculi, location of the calculi, size of the calculi, density of the calculi (Hounsfield Unit measurement >600), and the number of operative interventions performed. Data were analyzed with descriptive statistics, the chi-squared test, and unadjusted/adjusted logistic regression. Our study sample consisted of 147 patients (10.9% Caucasian, 55.8% Asian, and 33.3% Black African). Most patients (86.4%) were from urban areas. A higher proportion of Black Africans had urinary calculi with Hounsfield Unit measurements >600 (P = 0.002). In the logistic regression models, Black Africans had a higher probability of having urinary calculi with Hounsfield Unit measurements >600 (Unadjusted Odds Ratio: 7.17, 95% Confidence Interval: 2.00–27.80; Adjusted Odds Ratio: 18.75, 95% Confidence Interval: 3.37–157.57). Our analysis suggests that Black Africans are at higher risk of having harder urinary calculi than other race groups. This has implications for urolithiasis management and highlights the importance of primary prevention in this group. We recommend additional research to confirm our findings.

Keywords: characteristics; racial disparity; South Africa; Urinary calculi; Urolithiasis

Received: 01 April 2022; *Accepted after revision*: 06 April 2023; *Published*: 4 May 2023

Author for correspondence: Dhesigan Naidoo, Department of Urology, Nelson R. Mandela School of Medicine, University of KwaZulu-Natal, 719 Umbilo Road, Durban, South Africa. Email: drdnaidoo@gmail.com

How to cite: Naidoo D and Ramloutan V. Differences in Urinary Calculi Characteristics among the Three Main Racial Groups in KwaZulu-Natal, South Africa. J Ren Hepat Disord. 2023 7 (1): 38–43.

Doi: https://doi.org/10.15586/jrenhep.v7i1.142

Introduction

Urolithiasis is defined as the formation and/or presence of calculi in any part of the urinary system (1). It has been estimated that one in every 11 individuals residing in the United States experiences urolithiasis during his lifetime (2). Globally, the burden of urolithiasis is increasing, and Alatab et al. postulated that the increasing global burden of urolithiasis was due to urbanization and the adoption of western dietary habits by previous rural populations (3). Urolithiasis is associated with increased healthcare expenditures, and

disease management in the United States alone is estimated to cost up to $2 billion annually (4, 5).

Urolithiasis can be a debilitating condition, and patients may suffer an indirect economic cost from being unable to work (6). Short-term consequences of untreated urolithiasis include pain, renal colic, and hematuria. Acute disease might require hospitalization or emergency surgery (7). Its long-term consequences are more severe, and include pyelonephritis and chronic kidney disease (8, 9). Given the serious implications of urolithiasis and the growing burden of the condition, much attention has been given to understanding the underlying pathology of the disease.

It is well accepted that urolithiasis is multifactorial, with race being one of the proposed risk factors for the development of urinary calculi (10). Black populations have traditionally been considered to be at a lower risk for urolithiasis when compared with Caucasians (11, 12). In a South African study conducted during the early 2000s, Lewandowski et al. reported that "South African blacks are relatively immune to urinary stones" (12). The authors further hypothesized that the underlying protective mechanism in South African Blacks was related to oxalate absorption (12). Non-communicable disease burden, including that of renal disease, has increased among the Black African population in South Africa since the study of Lewandowski et al. (13, 14). At the same time, the non-communicable disease burden has remained static among the other racial groups comprising the South African population (14). These recent trends in non-communicable disease suggest that contemporary research around differences in urolithiasis among the various racial groups comprising the South African population is required.

Racial differences in the characteristics of urinary calculi are poorly described in the South African context (11). This paucity of knowledge limits our local understanding of urolithiasis pathology and thwarts our efforts in designing appropriate preventative interventions for high-risk racial groups. The objective of our study was to investigate differences in urinary calculi characteristics among the three main racial groups in KwaZulu-Natal, South Africa.

Materials and Methods

Research study design

Our study was a retrospective chart review of patients attending the urology unit of a South African quaternary hospital.

Setting

We conducted our research study at the Inkosi Albert Luthuli Central Hospital (IALCH) in the city of Durban, South Africa. As a government-funded quaternary hospital, IALCH offers specialist healthcare services on a referral basis to the population of KwaZulu-Natal Province. The population of KwaZulu-Natal is diverse, and comprised of Black Africans, Caucasians, and Asians (primarily individuals of South Asian descent).

Study sample

Our study sample consisted of consecutive patients who attended the urology unit of IALCH with urinary calculi during the period January 1, 2018–December 31, 2019. These patients were identified from the admissions log maintained in the urology unit. We excluded patients who were later found to have had missing data.

Data collection

We retrospectively collected data from the medical charts of patients who attended the urology unit at IALCH for the management of urinary calculi during the study period. An in-depth review of admission notes, progress notes, laboratory reports, and operation records was performed for each eligible patient. All data were entered directly onto an electronic spreadsheet. We collected data on the patient's age, sex, race, place of residence, and pre-stenting. We investigated five study outcomes across the various race groups: the number of calculi, location of the calculi, size of the calculi, the density of the calculi (Hounsfield Unit measurement), and the number of operative interventions performed. Calculi size was dichotomized using a threshold of 20 mm (15). Hounsfield Unit measurements were dichotomized using a threshold of 600—corresponding to a high density, calcium-based calculus (16).

Statistics

We performed our data analysis in R version 4.1.1 (R Foundation for Statistical Computing, Vienna, Austria). Where applicable, a $P < 0.050$ was considered a statistically significant result. Our statistical analysis plan included descriptive statistics for the study sample (median with interquartile range [IQR] or frequencies with %), a crude comparative analysis between race groups (chi-squared test), and unadjusted/adjusted logistic regression analyses to investigate the probability of the various study outcomes across race groups (Odds ratios with 95% confidence intervals). The adjusted logistic regression analysis controlled for the effects of age, sex, rural residence, and pre-stenting on the study outcomes. For the interpretation of odds ratios, an odds ratio >1.00 was considered an indicator of increased risk for the outcome being investigated. Conversely, an odds ratio <1.00 was considered an indicator of lower risk for the outcome being investigated.

Research ethics

Our research was reviewed and approved by the Biomedical Research Ethics Committee, University of KwaZulu-Natal (BREC/00002736/2021).

Results

After excluding 22 patients with missing data (either important characteristics or one of the study outcomes), our study sample consisted of 147 patients with urinary calculi who attended the urology unit at IALCH during 2018–2019 (Figure 1).

Regarding the overall characteristics of our study sample (Table 1), the median age of the study population was 49.0 years old (IQR: 36.0–58.0). There was a similar proportion of males and females (52.4% vs. 47.6%). Our descriptive analysis also revealed a multi-racial patient population (10.9% Caucasian, 55.8% Asian, and 33.3% Black African), with most of these patients residing in urban settings throughout KwaZulu-Natal. Approximately half of the study sample (48.3%) was pre-stented. Nearly one in every two patients (44.2%) had >1 urinary calculus. Most of the urinary calculi (74.8%) were located outside the kidney. Approximately one in every five patients (18.4%) had large calculi (>20 mm in diameter). Around half of all patients in our study sample (49.7%) had very dense urinary calculi with a Hounsfield Unit measurement >600. Finally, approximately half of the study sample (48.3%) had less than one visit to the operating room to remove urinary calculi.

We also conducted a crude statistical comparison of the various study outcomes across the three race groups (Table 2). The only statistically significant finding from the crude analysis was that there was a higher proportion of Black Africans who had urinary calculi with a Hounsfield Unit measurement >600 when compared with the other race groups (P = 0.002).

The results of our unadjusted logistic regression analysis suggested that Black Africans were seven times more likely to have a urinary calculus with a Hounsfield Unit measurement >600

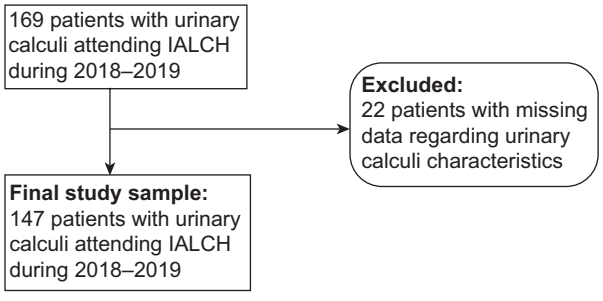

Figure 1: Patient flow diagram showing the derivation of our study sample (N = 147).

Table 1: Characteristics of our study sample (N = 147).

Characteristic	Descriptive statistic
Age in years	
Median (IQR)	49.0 (36.0–58.0)
Sex, n (% of N)	
Male	77 (52.4)
Female	70 (47.6)
Race, n (% of N)	
Caucasian	16 (10.9)
Asian	82 (55.8)
Black African	49 (33.3)
Rural residence, n (% of N)	
No	127 (86.4)
Yes	20 (13.6)
Pre-stented, n (% of N)	
No	76 (51.7)
Yes	71 (48.3)
Number of calculi	
Median, (IQR)	1.0 (1.0–2.0)
>1 Calculi, n (% of N)	
No	82 (55.8)
Yes	65 (44.2)
At least one calculus outside of kidney, n (%)	
No	37 (25.2)
Yes	110 (74.8)
Largest calculi size	
Median (IQR)	12.0 (7.0–17.7)
Calculi size >20 mm, n (% of N)	
No	120 (81.6)
Yes	27 (18.4)
Largest Hounsfield Unit measurement	
Median (IQR)	860.0 (560.0–1217.5)
Hounsfield Unit measurement >600, n (% of N)	
No	74 (50.3)
Yes	73 (49.7)

(*continues*)

Table 1: Continued

Characteristic	Descriptive statistic
Number of operating room visits	
Median (IQR)	1.0 (1.0–2.0)
>1 operating room visit, n (% of N)	
No	76 (51.7)
Yes	71 (48.3)

when compared with Caucasians (Table 3). On the other hand, we found that the unadjusted odds of having a urinary calculus with a Hounsfield Unit measurement >600 were similar between Asians and Caucasians. When we adjusted our analysis for confounders, we found that Black Africans were almost 19 times more likely to have a urinary calculus with a Hounsfield Unit measurement >600 when compared with Caucasians (Table 3). According to our findings from the unadjusted logistic regression analysis, there was no difference in the adjusted odds of having a urinary calculus with a Hounsfield Unit measurement >600 between Asians and Caucasians. We did not observe any other findings of interest from our unadjusted and adjusted logistic regression analyses (Table 3).

Discussion

The most important finding from our research was that Black Africans had a higher probability (7-fold higher unadjusted odds and 19-fold adjusted odds) of having harder urinary calculi with Hounsfield Unit measurements >600 when compared with Caucasians. In contrast, our finding for Asians suggests that they had urinary calculi of similar density to

Table 2: Crude comparison of study outcomes between race groups.

Study outcome, n (% of N)	Caucasian (N = 16)	Asian (N = 82)	Black African (N = 49)	P
>1 Calculi	10 (62.5)	33 (40.2)	22 (44.9)	0.259
Calculi outside of kidney	13 (81.2)	63 (76.8)	34 (69.4)	0.523
Calculi size >20 mm	3 (18.8)	10 (12.2)	14 (28.6)	0.064
Hounsfield Unit measurement >600	**8 (50.0)**	**51 (62.2)**	**43 (87.8)**	**0.002**[a]
>1 operating room visit	7 (43.8)	36 (43.9)	28 (57.1)	0.316

[a]Statistically significant at P < 0.050.

Table 3: Unadjusted and adjusted odds of various study outcomes according to race group.[a]

Study outcome	Caucasian	Asian	Black African
>1 Calculi, uOR (95%CI)	1.00 (Reference)	0.40 (0.13–1.19)	0.49 (0.15–1.53)
>1 Calculi, aOR (95%CI)	1.00 (Reference)	0.40 (0.12–1.27)	0.37 (0.09–1.37)
Calculi outside of kidney, uOR (95%CI)	1.00 (Reference)	0.82 (0.17–2.89)	0.52 (0.11–1.92)
Calculi outside of kidney, aOR (95%CI)	1.00 (Reference)	1.05 (0.21–4.02)	0.57 (0.10–2.50)
Calculi size >20 mm, uOR (95%CI)	1.00 (Reference)	0.60 (0.16–2.95)	1.73 (0.47–8.39)
Calculi size >20 mm, aOR (95%CI)	1.00 (Reference)	0.52 (0.12–2.72)	1.67 (0.36–9.42)
Hounsfield Unit measurement >600, uOR (95%CI)	1.00 (Reference)	1.65 (0.55–4.91)	**7.17 (2.00–27.80)**[b]
Hounsfield Unit measurement >600, aOR (95%CI)	1.00 (Reference)	2.14 (0.66–7.23)	**18.75 (3.37–157.57)**[c]
>One operating room visit, uOR (95%CI)	1.00 (Reference)	1.01 (0.34–3.06)	1.71 (0.55–5.52)
>One operating room visit, aOR (95%CI)	1.00 (Reference)	1.80 (0.48–7.08)	4.13 (0.89–20.70)

uOR: Unadjusted odds ratio, aOR: Adjusted odds ratio, 95%CI: 95% Confidence interval. [a]Adjusted logistic regression model controlled for age, sex, rural residence, and whether the patient was pre-stented or not; [b]P-value statistically significant (P = 0.003) on unadjusted analysis when compared with reference group (Caucasian); [c]P-value statistically significant (P = 0.002) on adjusted analysis when compared with reference group (Caucasian).

those of Caucasians. Therefore, we demonstrate at least one racial difference in urinary calculi characteristics between the main racial groups in KwaZulu-Natal, South Africa.

There is sparse data on urinary calculi composition in Black South Africans, and urologists have long assumed that hard calcium oxalate calculi are rare in the Black African racial group (11). A study of urinary calculi done in the city of Durban during 1979–1980 reported that only two of the 300 calculi analyzed were from Black Africans, with one of these confirmed as being a calcium oxalate calculus (11). The underlying mechanism conferring protection in this group is thought to be related to calcium oxalate metabolism in the gut (12). Our finding that 87.8% of urinary calculi in Black Africans had a density of >600 Hounsfield Units, and were thus likely comprised of calcium oxalate, is particularly interesting as it suggests that the hypothesized protective mechanism in this group is being overwhelmed. Advancements in the study of the gut microbiome have revealed that the gut of Black Africans is colonized by *Oxalobacter formigenes* and several other bacterial species capable of metabolizing calcium oxalate (17). The carriage rate of oxalate degrading bacteria among Black South Africans is estimated at 70% when compared with 10% in Caucasians (18). Published evidence suggests a 70% reduction in the risk of being a recurrent calcium oxalate stone former in *O. formigenes* carriers when compared to non-carriers (19). The gut microbiome is sensitive to changes in diet (20). It is therefore possible that urbanization (86.4% of our study sample resided in urban areas) and adoption of a western diet among Black Africans is slowly leading to lower carriage of *O. formigenes* and other oxalate metabolizing bacteria in this racial group, placing them at a risk of calcium oxalate urinary calculi. In addition, other urolithiasis risk factors may further exacerbate the reduced calcium oxalate metabolism in Black Africans with a lower carriage of *O. formigenes* or promote expansion of the urinary calculi through other known mechanisms.

While it is important that primary prevention for urolithiasis be strengthened across all racial groups in KwaZulu-Natal, it appears that additional focus must be placed on strengthening knowledge/awareness of urolithiasis and its risk factors among Black Africans. An intervention of this nature may promote the avoidance of risk factors, such as an unhealthy diet, in this racial group and will also draw attention to the potential signs and consequences of urolithiasis such that individuals are prompted to seek healthcare services at an early stage when the urinary calculi might not be very hard (i.e., calculi with high density/high Hounsfield Unit measurement) and easier to manage.

We did not find any other statistically significant differences between the three racial groups in terms of the other four outcomes investigated in our study. This might be due to the size of our study sample, which may have only allowed us to detect the strongest statistical associations between racial groups and the other study outcomes, while weaker statistical associations were missed. Another limitation of our study was that it was conducted at a quaternary hospital offering specialist care and our study sample might be very different from that of lower-level healthcare facilities where specialist care is not required. Finally, we did not investigate long-term outcomes in our study sample, as often the patients are discharged from our facility and do not return for follow-up at our outpatient clinic or their referral hospital. Such limitations must be considered when designing future research studies on this topic.

Conclusion

We found that Black Africans are at higher risk of having harder urinary calculi than the two other race groups (Caucasian and Asian) in KwaZulu-Natal. This finding has important implications for urolithiasis management in our setting and highlights the importance of strengthening knowledge/awareness of urolithiasis and its associated risk factors in this racial group. While our study provided useful contemporary information on differences in urinary calculi between the various racial groups, it was not without limitations. We therefore recommend that additional research on this topic, which will also address the limitations we have identified in our study, be done to confirm our findings.

Acknowledgement

This research is part of the master's degree studies of the first author.

Conflict of Interest

The authors declare no potential conflicts of interest with respect to research, authorship, and/or publication of this article.

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