African Journal of Nephrology
Official publication of the African Association of Nephrology
Volume 24, No 1, 2021, 68-74

ORIGINAL RESEARCH

Twenty four-hour urine collection is appropriate in a cohort of South African renal stone formers

Lisa Kaestner[1], John Lazarus[1], Elmi Muller[2]

[1]Division of Urology, University of Cape Town, South Africa; [2]Division of General Surgery, University of Cape Town, South Africa.

ABSTRACT

Objectives: To report the prevalence of metabolic abnormalities found in an urban South African population of stone formers and thereby determine whether international guidelines on 24-hour urine collection should be recommended for South African stone formers.

Methods: A retrospective folder review was conducted on patients who were admitted with renal stones or who had renal stone procedures between 1 November 2014 and 31 March 2020, with a confirmed history of renal calculi and who had 24-hour urine collection at a tertiary centre renal stone clinic. All confirmed stone formers were offered 24-hour urine collection once they were infection-free and stone-free. Demographics, 24-hour urine collection findings and stone analysis results (if available) were recorded. A 24-hour urine collection was performed once patients were stone-free while on their regular diet and routine lifestyle.

Results: 175 patients with metabolic studies were included (65 females and 110 males). The mean age was 53.8 ±13.6 years. The commonest metabolic risk factors were hypocitraturia (61.0%), hypomagnesiuria (41.1%), mild hypercalciuria (22.0%), and hyperuricosuria (20.2%). Hyperuricaemia, high urinary sodium excretion, mild hypercalciuria and hyperuricosuria were more common in men. A total of 102 patients had both 24-hour urine collection and stone analysis for comparison. There were no differences between different stone types in the prevalence of metabolic risk factors except for hyperuricaemia and high urinary sodium excretion, which were both higher in uric acid predominant stone formers.

Conclusion: The prevalence of risk factors was high and seemed similar to that of other populations, except for a higher prevalence of hypocitraturia. Internationally recommended guidelines for 24-hour urine studies are therefore applicable and appropriate for this population. Risk factors seem similar across stone types; however, a larger study is necessary to clarify whether metabolic risk factors are useful to predict stone composition.

Keywords: 24-hour collection; renal stones; Africa; risk factors.

INTRODUCTION

Numerous publications have investigated a purported low incidence of stones in South Africans [1-4]. Historically, legislative segregationist policies during the 1940s to 1990s in South Africa created great socio-economic and healthcare disparities among races. Many small studies investigated the relationship between race and urolithiasis risk in Black South Africans, who were considered "non-forming patients", and White South Africans [5-7]. Very few epidemiological data on nephrolithiasis in South Africa exist [8]. Just two studies have reported on 24-hour urine collection in South African stone formers in the past 25 years [9,10]. The most recent study, published in 2004, included only White and Indian patients [9]. According to Statistics South Africa estimates in 2019, these two population groups represented 7.9% and 2.6%, respectively, of an estimated South African population of 58.7 million [11]. Thus, these two population groups are not representative of the

Received 17 February 2021; accepted 11 October 2021; published 15 December 2021.
Correspondence: Lisa Kaestner, La.kaestner@uct.ac.za.

ethnically and socio-economically diverse South African population. All patients included had at least one metabolic risk factor for nephrolithiasis. Low urine volume, hyperuricaemia, hypomagnesuria and hypocitraturia were the commonest risk factors reported. Hypercalciuria was reported in only 7%, although patients with mild hypercalciuria, as defined in the European Association of Urology (EAU) guidelines, were not identified [9]. In another South African study, by Whalley et al. in 1999, which included a more diverse group of patients, hypocitraturia (43%), hyperoxaluria (21%) and hypercalciuria (20%) were the commonest risk factors noted on 24-hour urine collection [12].

A systemic review by Huynh et al., comparing the prevalence of risk factors for nephrolithiasis reported before and after 2000, showed a relative increase in risk factor prevalence since 2000 [13]. In the post-2000 group, the commonest risk factors were hyperoxaluria (33%), hypercalciuria (36%), hyperuricosuria (22%), low urine volume (38%), and hypocitraturia (44%) [13]. Of the 28 articles included, only one South African study, a paper by Laminski et al. published in 1991, was included in this review. This study investigated risk factors in hyperoxaluric recurrent calcium oxalate stone formers [14].

Metabolic evaluation with 24-hour urine collection is recommended by both the American Urology Association (AUA) and EUA in the assessment of high-risk stone formers [15]. These guidelines are based on data from Europe, America, and Asia but it is unclear whether these guidelines are applicable and appropriate for stone formers in Africa. Multiple authors have reported that 24-hour urine collection does not predict recurrent stones [16,17]. A recent large population-based study reported that completion of a 24-hour urine collection was not associated with a decrease in stone recurrence rates even in high-risk stone formers [18]. However, there is a strong recommendation by the EAU, supported by high-level evidence, for the medical management of metabolic risk factors such as hypocitraturia, hyperuricosuria and hypercalciuria detected on 24-hour urine collection [19]. An observational study by Song et al. reported that patients are more likely to receive medical management to reduce stone risk after 24-hour urine collection [20]; however, there is no randomised controlled evidence which confirms that stone recurrence is reduced by full metabolic evaluation in renal stone formers. Although 24-hour urine collection may not predict recurrence in large-population studies, there is robust evidence that medical management of risk factors identified on 24-hour urine collection reduces stone recurrence [19].

A 24-hour urine collection is a relatively high-cost investigation in our resource-constrained, state-funded healthcare system and it is inconvenient for patients. Patients who live in informal housing may not have easy access to bathroom facilities for complete specimen collection. Furthermore, the cost of travelling to the hospital to deliver the sample, even if distances are short, may be prohibitive for many of the unemployed patients who use our service. It is unclear also whether 24-hour collection is necessary and appropriate for renal stone formers treated in our hospitals.

There are no recent publications which report basic epidemiology of nephrolithiasis in the South African population.

The aim of this study was to report the prevalence of metabolic abnormalities found in an urban South African population of stone formers admitted for stone procedures and thereby determine whether 24-hour urine collection should be recommended for the stone formers. We sought also to record sex differences in urine biochemistry and metabolic stone risk factors and to explore whether metabolic risk factor prevalence differs among calcium predominant stone formers (CP) as well as uric acid predominant (UP) and other predominant (OP, infection-related and cystine) stone formers.

METHODS

Patients were identified from a prospectively collected database of patients who were admitted for renal stones or who had had surgery for renal stones between November 2014 and March 2020 at Groote Schuur Hospital in Cape Town, South Africa. This hospital is a state-funded referral centre which serves patients who live in the Metro West area of the Cape Town metropolitan area. Most of these patients are uninsured and access free health care or at income-adjusted rates. Renal stone patients are followed up in a renal stone clinic, which sees approximately 160 patients per month. All confirmed renal stone formers seen at the renal stone clinic are offered 24-hour urine studies once they are free of stones and infection while on their regular diet and routine lifestyle.

A retrospective folder review was conducted on all patients who had been admitted to hospital with or had had surgery for a renal calculus (whether a stone was analysed or not) and in whom a 24-hour urine collection had been performed. Demographics, 24-hour urine collection findings and stone analysis results (if available) were recorded from patient folders, patient administrative records and the online laboratory results portal.

Stones were analysed at PathCare laboratories (outsourced by the National Health Laboratory Service) using Fourier transform infrared (FTIR) spectroscopy (Agilent Technologies, Cary 630 FT-IR spectrometer). The 24-hour urine

volume and concentration of components were measured according to a standard protocol by the National Health Laboratory Service. Calcium, magnesium and phosphate were measured spectrophotometrically and uric acid, oxalate and citrate were recorded enzymatically.

Reference ranges, as reported by Straub et al. and EAU guidelines, were used for all serum and 24-hour urine values, except 24-hour urine sodium excretion, which was based on the NHS Laboratory Service reference range [19,21].

If 24-hour creatinine excretion was less than 5 mmol per day or if 24-hour excretion was less than 6 mmol per day and the total volume was less than 1000 mL, the collection was considered incomplete and the results were excluded [22]. This was used for quality control as body weight was not available to allow for the calculation of a creatinine index. (Creatinine index is calculated using creatinine excretion, weight and sex and is a more reliable index of complete 24-hour collection than self-reported complete collection and urine volume [23].)

Statistical analyses were performed using IBM® SPSS version 26. Continuous variables were reported as means ± standard deviation. Categorical values were reported as percentages. Groups with normal distribution were compared using independent, 2-tailed t-test or one-way ANOVA, if more than two groups were being compared. The Mann–Whitney U test was used to compare continuous variables which were not normally distributed. Pearson's chi-squared test was used to assess the relationship between categorical variables. Where one or more cells were less than or equal to five, Fisher's exact test was used. A difference was considered statistically significant for $P < 0.05$. Values missing completely at random (MCAR) were managed by pairwise deletion during analysis. Most values seemed missing due to omissions and variations on laboratory request forms by attending urologists. This pro-tocol was reviewed by an institutional review board (HREC reference: 240/2020).

RESULTS

A total of 184 patients with metabolic studies were identified from a prospectively collected database of patients who were admitted or who had had surgery for renal stones at Groote Schuur Hospital. Most patients identified themselves as of mixed ethnicity (81.5%, 150/184), 9.8% (18/184) identified as African, 4.3% (8/184) identified as White and 1.6% (3/184) identified as Asian; 5/184 (2.7%) did not declare their ethnicity.

Of the 184 studies, nine were excluded due to under-collection, leaving 175 patients with metabolic studies included (65 females and 110 males). Their mean (SD) age was 53.8 (13.6) years.

There was a high prevalence of metabolic risk factors detected on 24-hour urine studies (Table 1). The commonest risk factors were hypocitraturia (61.0%), hypomagnesiuria (41.1%), mild hypercalciuria (22.1%) and hyperuricosuria (20.2%).

There were no differences in the prevalence of hypercalcaemia, hypercalciuria, hyperoxaluria, hyperphosphaturia, hypocitraturia or hypomagnesiuria between male and female stone formers. More women had urine volumes below 1.5 L per 24 hours. Hyperuricaemia, high urinary sodium excretion, mild hypercalciuria and hyperuricosuria were more common in men (Table 1).

There were no differences in the age distribution, serum calcium, 24-hour urine citrate excretion and creatinine clearance between male and female stone formers. Male patients recorded significantly higher serum uric acid and serum creatinine. They produced higher volumes of urine and excreted more sodium, uric acid, oxalate, magnesium and phosphate per day than female stone formers (Table 2).

Of the 175 patients, 102 had both 24-hour urine collection and stone analysis for comparison. Of these, 77 (75.4%) were calcium predominant (CP) stone formers, 15 (14.7%) were uric acid predominant (UP) stone formers, and 10 (9.8%) were "other" predominant (OP). The OP group included infection-related stone formers and 2 patients with cystine stones admixed with calcium phosphate. There was a male predominance in both calcium and UP stone formers and a female predominance in the "other" group (mostly infection-related stones). UP stone formers appeared older (60.2 ± 9.7 years) than CP (51.3 ± 13.9) and OP (52.9 ± 13.5) stone formers, although this difference did not reach significance ($P = 0.070$).

There were no differences among different stone types for serum calcium, serum creatinine, urine 24-hour volume, urine 24-hour sodium, urine 24-hour uric acid, urine 24-hour citrate, urine 24-hour magnesium, or urine 24-hour phosphate excretion (Table 3).

There were significant differences among stone types in serum uric acid ($P = 0.040$), urine 24-hour calcium excretion ($P = 0.014$), urine 24-hour oxalate ($P = 0.013$) and creatinine clearance ($P = 0.038$). Although median serum uric acid was higher in UP stone formers (0.38 mmol/L, IQR 0.31-0.44) versus CP (0.32 mmol/L, IQR 0.28-0.39) and OP (0.31 mmol/L, IQR 0.21-0.32), 24-hour urine uric acid excretion was not significantly different across stone types (Table 3).

Table 1. Prevalence of risk factors in all patients on metabolic evaluation.

	All n/ N (%)	Female n/ N (%)	Male n/ N (%)	P value
All N (%)	175	65 (37.1)	110 (62.9)	
Serum				
Hypercalcaemia (> 2.5 mmol/L)	29/170 (17.1)	12/63 (19.0)	17/107(15.9)	0.371†
Hyperuricaemia (> 0.38 mmol/L)	23/163 (35.6)	14/61 (23.0)	44/102(43.1)	0.009†
Urine				
Low urine volume (< 1.5 L per 24 hours)	23/175 (13.1)	14/65 (21.5)	9/110 (8.2)	0.012†
Hypernatriuria (> 220 mg per 24 hours)	23/174 (13.2)	2/65 (3.1)	21/109 (19.3)	0.002†
Mild hypercalciuria (> 5 mmol per 24 hours)	38/172 (22.1)	8/63 (12.7)	30/109 (27.5)	0.024†
Hypercalciuria (> 8 mmol per 24 hours)	9/172 (5.2)	2/63 (3.2)	7/109 (6.4)	0.489‡
Hyperoxaluria (> 0.5 mmol per 24 hours)	13/173 (7.5)	2/65 (3.1)	11/108 (10.2)	0.135‡
Hyperuricosuria (> 4 mmol per 24 hours)	34/168 (20.2)	7/60 (11.7)	27/108 (25.0)	0.039†
Hyperphosphaturia (> 35 mmol per 24 hours)	16/173 (9.2)	3/65 (4.6)	13/108 (12.0)	0.103†
Hypocitraturia (< 2.5 mmol per 24 hours)	105/172 (61.0)	41/65 (63.1)	64/107 (59.8)	0.670†
Hypomagnesiuria (< 3 mmol per 24 hours)	67/163 (41.1)	30/59 (50.8)	37/104 (35.6)	0.057†

Abbreviations: n, number with abnormality; N, number available for inclusion. †Pearson's chi-squared test. ‡Fisher's exact test.

Table 2. 24-hour urine study findings and demography of renal stone formers (with or without stone analyses).

		All (N = 175)	Female (N = 65)	Male (N = 110)	P value
Age (years)	mean ± SD	54 ± 14	55 ± 15	53 ± 13	0.429†
Serum*					
Calcium (mmol/L)	Median (IQR)	2.41 (2.33-2.47)	2.39 (2.31-2.47	2.41 (2.34-2.47)	0.293‡
Uric acid (mmol/L) Creatinine	Median (IQR)	0.34 (0.28-0.44)	0.31 (0.27-0.37)	0.36 (0.31-0.45	0.002‡
(µmol/L)	Median (IQR)	83.5 (73-102)	75 (60-89)	87 (79-106)	0.000‡
Urine**					
Volume (ml per 24 hours)	Median (IQR)	2000 (1750-2790)	2000 (1550-2510)	2110 (1800-2900)	0.026‡
Sodium (mmol per 24 hours)	Median (IQR)	147 (106-200)	131 (89-171)	171 (122-212)	<0.001‡
Calcium (mmol per 24 hours)	Median (IQR)	3.32 (2.23-4.70)	3.22 (2.23-4.21)	3.34 (2.22-5.19)	0.329‡
Uric acid (mmol per 24 hours)	Median (IQR)	2.70 (2.01-3.67)	2.44 (1.77-3.13)	2.95 (2.08-4.01)	0.002‡
Oxalate (mmol per 24 hours)	Median (IQR)	0.300 (0.235-0.376)	0.274 (0.213-0.324)	0.321 (0.260-.409)	<0.001‡
Citrate (mmol per 24 hours)	Median (IQR)	1.95 (1.10-3.10)	1.80 (0.85-2.90)	2.20 (1.20-3.30)	0.217‡
Magnesium (mmol per 24 hours)	Median (IQR)	3.20 (2.64-4.12)	2.90 (2.21-3.81)	3.33 (2.79-4.40)	0.014‡
Phosphate (mmol per 24 hours)	Median (IQR)	21.93 (14.33-28.57)	19.49 (11.86-24.24)	23.7 (16.58-30.67)	0.001‡
Creatinine clearance (ml/min)	Median (IQR)	99.4 (73.5-124.7)	91.4 (63.1-125.9)	106.5 (82.4-124.3)	0.082‡

*Some analytes were not measured in all patients, n missing (%): calcium 5 (3%), uric acid 12 (7%).
**Some analytes were not measured in all patients, n missing (%): sodium 1 (1%), calcium 3 (2%), uric acid 7 (4%), oxalate 2 (1%), citrate 3 (2%), magnesium 12 (7%), phosphate 2 (1%). SD, standard deviation; IQR, interquartile range. †Independent samples (2-tailed) t-test. ‡Independent samples Mann–Whitney U test.

Table 3. Comparison of 24-hour urine study findings and demography of renal stone formers by predominant stone composition.

		All	Calcium predominant	Uric acid predominant	Other predominant	P value
All	N (%)	102	77 (75.4)	15 (14.7)	10 (9.8)	
Sex						
Female	N (%)	38	28 (36.4)	2 (13.3)	8 (80.0)	0.003†
Male	N (%)	64	49 (63.6)	13 (86.7)	2 (20.0)	
Age (years)	mean ± SD	52.8 (13.5)	51.3 (13.9)	60.2 (9.7)	52.9 (13.5)	0.070‡
Serum*						
Calcium (mmol/L)	Median (IQR)	2.40 (2.33-2.46)	2.40 (2.34-2.47)	2.42 (2.33-2.47)	2.35 (2.23-2.42)	0.165◊
Uric acid (mmol/L)	Median (IQR)	0.32 (0.28-0.39)	0.32 (0.28-0.39)	0.38 (0.31-0.44)	0.31 (0.21-0.32)	0.040◊
Creatinine (µmol/L)	Median (IQR)	83 (73-101)	81 (73-95)	101 (76-147)	83 (73-101)	0.181◊
Urine**						
Volume (mL)	Median (IQR)	2000 (1800-2825)	2000 (1800-2900)	1920 (1680-2790)	2100 (1950-2685)	0.802◊
Sodium (mmol per 24 hours)	Median (IQR)	40 (109-192)	146 (113-187)	169 (107-257)	118 (101-160)	0.297◊
Calcium (mmol per 24 hours)	Median (IQR)	3.64 (2.59-4.70)	3.79 (2.83-4.90)	2.73 (1.99-3.85)	2.70 (1.18-3.43)	0.014◊
Uric acid (mmol per 24 hours)	Median (IQR)	2.67 (2.07-3.48)	2.63 (2.07-3.44)	3.16 (2.37-4.03)	2.08 (1.39-3.54)	0.136◊
Oxalate (mmol per 24 hours)	Median (IQR)	0.292 (0.233-0.371)	0.302 (0.238-0.374)	0.296 (0.230-0.394)	0.227 (0.172-0.272)	0.013◊
Citrate (mmol per 24 hours)	Median (IQR)	1.90 (1.17-3.20)	1.90 (1.25-2.90)	3.20 (1.30-3.90)	1.25 (0.15-2.50)	0.065◊
Magnesium (mmol per 24 hours)	Median (IQR)	3.16 (2.72-4.10)	3.27 (2.74-3.99)	2.99 (2.51-4.64)	3.11 (2.47-4.12)	0.838◊
Phosphate (mmol per 24 hours)	Median (IQR)	22.09 (15.75-26.75)	22 (16.50-26.69)	23.71 (16.04-30.55)	19.37 (11.36-25.98-)	0.429◊
Creatinine clearance (mL/min)	Median (IQR)	99.7 (73.8-124.4)	104.2 (81.6-125.4)	100.7 (62.4-125.4)	68.2 (53.4-84.7)	0.038◊

*Some analytes were not measured in all patients, n missing (%): calcium 3 (3%), uric acid 9 (9%), creatinine 3 (3%).
**Some analytes were not measured in all patients, n missing (%): sodium 1 (1%), calcium 2 (2%), uric acid 4 (4%), oxalate 1 (1%), magnesium 8 (8%), phosphate 2 (2%).
†Pearson's chi-squared test. ‡One-way ANOVA. ◊Independent samples Kruskal–Wallis test.

There was no difference in the proportion of patients with metabolic risk factors diagnosed on 24-hour urine study between CP, UP and OP groups except for hyperuricaemia and high urinary sodium excretion, which were both higher in UP stone formers (Table 4).

DISCUSSION

The sex-related differences in 24-hour urine collection results are not unexpected and have been reported previously (Table 2) [13]. As urine sodium excretion reflects sodium intake, this finding suggests a high sodium diet in male stone formers. High sodium excretion may be associated with hypercalciuria and therefore also accounts for the high prevalence of mild hypercalciuria in men [21].

Most patients had a metabolic risk factor which requires medical management according EAU guidelines [19]. Without 24-hour urine collection, these patients would not have been identified for interventions to prevent stone recurrence.

The prevalence of hypercalciuria and hyperuricosuria seemed similar to international reports (Table 1). South African patients appeared to have a higher prevalence of hypocitraturia, and lower prevalence of hyperoxaluria and low urine volume. The higher urine volume may be due to the "stone clinic effect" as all patients reviewed were managed in a dedicated stone clinic. A higher prevalence of hypocitraturia has been reported by Huynh et al. in "non-Western" populations, although this group also reported a higher prevalence of hyperoxaluria in this group. The difference in prevalence of hyperoxaluria may be partially explained by the higher reference used as the upper limit of normal in this study.

When comparing our contemporary cohort with the 1999 report of risk factors in South African stone formers of Whalley et al., hypercalciuria seemed similar (22.1% vs 21.0%); however, the prevalence of hypocitraturia was higher (61.0% vs 43.0%) and the prevalence of hyperoxaluria was lower (7.5% vs 21.0%), respectively (Table 1)

Table 4. Comparison of proportion of patients per predominant stone component with metabolic disorder on 24-hour urine collection study.

	All n/N (%)	Calcium predominant n/N (%)	Uric acid predominant n/N (%)	Other n/N (%)	P value
All N (%)	102	77 (75.4)	15 (14.7)	10 (9.8)	
Serum					
Hypercalcaemia (> 2.5 mmol/L)	19/99 (19.2)	15/74 (20.3)	3/15 (20.0)	1/10(10.0)	0.833†
Hyperuricaemia (> 0.38 mmol/L)	25/93 (26.9)	18/69 (26.1)	7/15 (46.7)	0	0.040†
Urine					
Low urine volume (< 1.5 L per 24 hours)	10/102 (9.8)	8/77 (10.4)	1/15 (6.7)	1/10 (10.0)	1.000†
Hypernatriuria (> 220 mg per 24 hours)	10/101 (9.9)	5/76 (6.6)	4/15 (26.7)	1/10 (10.0)	0.048†
Hypercalciuria (> 8 mmol per 24 hours)	4/100 (4.0)	3/75 (4.0)	0	1/10 (10.0)	0.432†
Mild hypercalciuria (> 5 mmol per 24 hours)	19/100 (19.0)	15/75 (20.0)	3/15 (20.0)	1/10 (10.0)	0.832†
Hyperoxaluria (> 0.5 mmol per 24 hours)	8/101 (7.9)	7/77 (9.1)	1/14 (7.1)	0	1.000†
Hyperuricosuria (> 4 mmol per 24 hours)	15/98 (15.3)	9/74 (12.2)	4/15 (26.7)	2/9(22.2)	0.233†
Hyperphosphaturia (> 35 mmol per 24 hours)	9/100 (9.0)	6/75 (8.0)	1/15 (6.7)	2/10 (20.0)	0.401†
Hypocitraturia (< 2.5 mmol per 24 hours)	62/102 (60.8)	48/77 (62.3)	5 (40.0)	8/10 (80.0)	0.138†
Hypomagnesiuria (< 3 mmol per 24 hours)	38/94 (40.4)	28/73 (38.4)	7/13 (53.8)	3/8 (37.5)	0.566†

Abbreviations: n, number with abnormality; N, number available for inclusion. †Fisher's exact test.

[12]. The difference in hyperoxaluria can be explained by the difference in the upper limit of the normal range used (0.35 mmol per day vs 0.5 mmol per day). This study has used the latest "normal" values quoted in the EAU 2021 guidelines [24]. The increase in hypocitraturia is in keeping with the trend reported by Huynh et al. [13]. Hypocitraturia may be caused by multiple factors including acid–base imbalance, medication, high sodium intake, hypokalaemia, hypomagnesiuria and genetics [25]. Considering that the South African diet is high in sodium and low in both magnesium and potassium, it is likely that dietary factors are the largest driver of hypocitraturia in our population [26].

The only risk factor which was significantly different across stone types was higher urinary sodium excretion in cases of uric acid predominant stones (Table 4) [21]. High urine sodium excretion is more commonly reported as a risk factor for calcium nephrolithiasis and this difference cannot be explained. High sodium intake in South Africans has been reported [27]. The absence of other differences in risk factors between stone types confirms similar findings in other populations [16,17]. Urine supersaturation is a good predictor of stone composition, although we did not have urine pH available to complete this calculation [28].

This study is limited by the retrospective design and the lack of inclusion of urine pH and patient weight, which could have been helpful as a quality control to determine under- and over-collections of the 24-hour urine sample. The inclusion of nephrolithiasis risk factors such as diet, socio-economic status and comorbid illness may have allowed adjustment for these confounders in this study. A larger study, powered for multinomial correlation of 24-hour collection variables, may confirm whether single variables or a combination of variables can discriminate among different types of stone formers.

CONCLUSION

The prevalence of metabolic risk factors, which can be modified by treatment to reduce stone recurrence, is high in this population. Risk factor prevalences seem similar to those of other populations, except for a higher prevalence of hypocitraturia. Internationally recommended guidelines for 24-hour urine studies are therefore applicable and appropriate for our study population. Risk factors seem similar across stone types; however, a larger study is necessary to clarify whether metabolic risk factors are useful to predict stone composition.

Conflicts of interest

No conflicts of interest to declare.

REFERENCES

1. Modlin M. The aetiology of renal stone: a new concept arising from studies on a stone-free population. Ann R Coll Surg Engl. 1967; 40:155-178.
2. Wise RO, Kark AE. Urinary calculi and serum calcium levels in Africans and Indians. S Afr Med J. 1961; 35:47-50.
3. Vermooten V. The occurrence of renal calculi and their possible relation to diet: as illustrated in the South African negro. JAMA. 1937; 109:857-859.
4. Lazarus J, Kaestner L. Towards solving the riddle of nephrolithiasis: a South Africa perspective. S Afr J Surg. 2020; 58:213-215.
5. Theka T, Rodgers A, Ravenscroft N, Lewandowski S. Intestinal permeability in subjects from two different race groups with diverse stone-risk profiles. Urolithiasis. 2013; 41:111-117.
6. Rodgers AL, Lewandowski S. Effects of 5 different diets on urinary risk factors for calcium oxalate kidney stone formation: evidence of different renal handling mechanisms in different race groups. J Urol. 2002; 168:931-936.
7. Theka T, Rodgers AL, Webber D, O'Ryan C. Variability in kidney stone incidence between black and white South Africans: AGT Pro11Leu polymorphism is not a factor. J Endourol. 2014; 28:577-581.
8. Rodgers A. Epidemiology: South Africa and Sub-Saharan Africa. ed. In: Talati J, Tiselius H-G, Albala DM, Ye Z, editors. Urolithiasis. London: Springer; 2012.
9. Abdel Goad EH, Bereczky ZB. Metabolic risk factors in patients with renal stones in KwaZulu Natal: an inter-racial study (Asian and Whites). BJU Int. 2004; 93:120-123.
10. Whalley NA, Moraes MF, Shar TG, Pretorius SS, Meyers AM. Lithogenic risk factors in the urine of black and white subjects. Br J Urol. 1998; 82:785-790.
11. Maluleke R. Mid-year population estimates 2019. Statistics South Africa. https://www.statssa.gov.za/publications/P0302/P03022019.pdf. Accessed 11 August 2021.
12. Whalley NA, Martins MC, Van Dyk RC, Meyers AM. Lithogenic risk factors in normal black volunteers, and black and white recurrent stone formers. BJU Int. 1999; 84:243-248.
13. Huynh LM, Dianatnejad S, Tofani S, Carrillo Ceja R, Liang K, Tapiero S, et al. Metabolic diagnoses of recurrent stone formers: temporal, geographic and gender differences. Scand J Urol. 2020; 54:456-462.
14. Laminski NA, Meyers AM, Kruger M, Sonnekus MI, Margolius LP. Hyperoxaluria in patients with recurrent calcium oxalate calculi: dietary and other risk factors. Br J Urol. 1991; 68:454-458.
15. Hughes T, Ho HC, Pietropaolo A, Somani BK. Guideline of guidelines for kidney and bladder stones. Turk J Urol. 2020; 46:S104-S112.
16. Trinchieri A, Ostini F, Nespoli R, Rovera F, Montanari E, Zanetti G. A prospective study of recurrence rate and risk factors for recurrence after a first renal stone. J Urol. 1999; 162:27-30.
17. Moreira DM, Friedlander JI, Hartman C, Elsamra SE, Smith AD, Okeke Z. Using 24-hour urinalysis to predict stone type. J Urol. 2013; 190:2106-2111.
18. Samson PC, Holt SK, Hsi RS, Sorensen MD, Harper JD. The association between 24-hour urine and stone recurrence among high risk kidney stone formers: a population level assessment. Urology. 2020; 144:71-76.
19. Skolarikos A, Straub M, Knoll T, Sarica K, Seitz C, Petrik A, et al. Metabolic evaluation and recurrence prevention for urinary stone patients: EAU guidelines. Eur Urol. 2015; 67:750-763.
20. Song S, Thomas IC, Ganesan C, Sohlberg EM, Chertow GM, Liao JC, et al. Twenty-four hour urine testing and prescriptions for urinary stone disease-related medications in veterans. Clin J Am Soc Nephrol. 2019; 14:1773-1780.
21. Straub M, Strohmaier WL, Berg W, Beck B, Hoppe B, Laube N, et al. Diagnosis and metaphylaxis of stone disease. Consensus concept of the National Working Committee on Stone Disease for the upcoming German Urolithiasis Guideline. World J Urol. 2005; 23:309-323.
22. Reinivuo H, Valsta LM, Laatikainen T, Tuomilehto J, Pietinen P. Sodium in the Finnish diet: II trends in dietary sodium intake and comparison between intake and 24-h excretion of sodium. Eur J Clin Nutr. 2006; 60:1160-1167.
23. John KA, Cogswell ME, Campbell NR, Nowson CA, Legetic B, Hennis AJ, et al. Accuracy and usefulness of select methods for assessing complete collection of 24-hour urine: a systematic review. J Clin Hypertens. 2016; 18:456-467.
24. European Association of Urology. EAU Guidelines. EAU Guidelines Office. http://uroweb.org/guidelines/compilations-of-all-guidelines/. Accessed 1 August 2021.
25. Zuckerman JM, Assimos DG. Hypocitraturia: pathophysiology and medical management. Rev Urol. 2009; 11:134-144.
26. Charlton KE, Steyn K, Levitt NS, Zulu JV, Jonathan D, Veldman FJ, et al. Diet and blood pressure in South Africa: Intake of foods containing sodium, potassium, calcium, and magnesium in three ethnic groups. Nutrition. 2005; 21:39-50.
27. Wentzel-Viljoen E, Steyn K, Ketterer E, Charlton KE. "Use salt and foods high in salt sparingly": a food-based dietary guideline for South Africa. S Afr J Clin Nutr. 2013; 26:S105-113.
28. Parks JH, Coward M, Coe FL. Correspondence between stone composition and urine supersaturation in nephrolithiasis. Kidney Int. 1997; 51:894-900.