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Research Article

Current Detection of Crystals and Bacteria in Urine during Urinary Tract Infections in Libreville, Gabon

Identification des Cristaux et des Bactéries dans l'Urine lors d'Infections Urinaires à Libreville, Gabon

Gaël Mourembou[1], Guy Francis Nzengui-Nzengui[1], Claudine Ayawa Kombila-Koumavor[1], Hervé Kamdem-M'boyis[1], Sydney Maghendji-Nzondo[2], Angélique Ndjoyi-Mbiguino[1]

Affiliations

1. Department of Bacteriology-Virology; Faculty of Medicine and Health Sciences; University of Health Sciences; B.P. 4009 Libreville, Gabon.
2. Department of Epidemiology, Biostatistics and Medical Informatics; Faculty of Medicine and Health Sciences; University of Health Sciences; B.P. 4009 Libreville, Gabon.

Corresponding Author
Mourembou Gaël; Département de Bactériologie-Virologie; Faculté de Médecine et des Sciences de la Santé; Université des Sciences de la Santé, B.P. 4009 Libreville, Gabon.
E-mail: gaelmourembou@yahoo.fr

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ABSTRACT

Introduction. In Gabon, no studies have yet identified the crystals and bacteria found in urine during urinary tract infections in Libreville. The aim of this study is to identify the crystals and bacteria commonly found during urinary tract infections and to measure their prevalence, as well as the correlation existing between these crystals and bacteria. **Methods.** This was an observational Study on patients, aged between three months to 83 years old, who consulted between 1995 and 2015 at the Bacteriology Laboratory of the Bacteriology and Virology Department of Libreville Health Sciences University in Gabon for a urine cytobacterial analysis. **Results.** We collected 1262 urine samples. Crystals were identified in 249 (19.7%) patients. Calcium oxalate and uric acid were the most commonly found crystals in 167 (13.2%) and 32 cases (2.5%), respectively. Crystal mixtures were found in 22 patients, including seven cases of calcium oxalate-uric acid (OxCalAcUr) and four cases of calcium oxalate-struvite (OxCalStruvite). Crystals were more often detected in patients with urinary tract infections than those without, (23.3%, P=0.03). Bacteria were isolated in 32% of patients (404/1262). They belonged mainly to the *Escherichia* (9.6%; 121 cases), *Staphylococcus* (7%; 89 cases), *Streptococcus* (5%; 63 cases) and *Klebsiella* (3%; 38 cases) genera. Urinary tract infections were common in patients over 60 years old and in those with alkaline urine pH. Women were more likely to be infected. **Conclusion.** Crystals and bacteria, especially *E. coli*, are common and often coexist in patients experiencing urinary tracts infections in Libreville, Gabon. Further studies should evaluate the relationship between bacteria and kidney stones in lithiasis patients in Gabon.

RESUME

Introduction. Au Gabon, aucune étude n'a encore identifié les cristaux et les bactéries retrouvés dans les urines au cours des infections urinaires à Libreville. Le but de cette étude est d'identifier les cristaux et les bactéries fréquement retrouvés lors des infections urinaires. **Méthodologie**. Il s'agit d'une étude observationnelle sur des patients, âgés de trois mois à 83 ans, qui ont consulté entre 1995 et 2015 au laboratoire de bactériologie du service de bactériologie et de virologie de l'université des sciences de la santé de Libreville au Gabon pour une analyse cytobactérienne des urines. **Résultats**. Nous avons collecté 1262 échantillons d'urine. Des cristaux ont été identifiés chez 249 patients (19,7%). L'oxalate de calcium et l'acide urique étaient les cristaux les plus fréquemment trouvés dans 167 (13,2 %) et 32 cas (2,5 %), respectivement. Des mélanges de cristaux ont été trouvés chez 22 patients, dont sept cas d'oxalate de calcium-acide urique (OxCalAcUr) et quatre cas d'oxalate de calcium-struvite (OxCalStruvite). Les cristaux ont été plus souvent détectés chez les patients souffrant d'une infection urinaire que chez ceux qui n'en souffraient pas (23,3 %, P=0,03). Des bactéries ont été isolées chez 32% des patients (404/1262). Elles appartenaient principalement aux genres Escherichia (9,6% ; 121 cas), Staphylococcus (7% ; 89 cas), Streptococcus (5% ; 63 cas) et Klebsiella (3% ; 38 cas). Les infections urinaires étaient fréquentes chez les patients âgés de plus de 60 ans et chez ceux dont le pH urinaire était alcalin. Les femmes étaient plus susceptibles d'être infectées. **Conclusion.** Les cristaux et les bactéries, en particulier E. coli, sont fréquents et coexistent souvent chez les patients souffrant d'infections urinaires à Libreville, au Gabon. D'autres études devraient évaluer la relation entre les bactéries et les calculs rénaux chez les patients porteurs de lithiase au Gabon.

HIGHLIGHTS

What is known of the subject

In Libreville, no studies have yet identified the crystals and bacteria found in urine during urinary tract infections.

The aim of our study

Distribution of crystals and bacteria commonly found during urinary tract infections.

Key Results

1. We collected 1262 urine samples. Crystals were identified in 249 (19.7%) patients.
2. Calcium oxalate and uric acid were the most commonly found crystals in 167 (13.2%) and 32 cases (2.5%), respectively. Crystal mixtures were found in 22 patients, including seven cases of calcium oxalate-uric acid (OxCalAcUr) and four cases of calcium oxalate-struvite (OxCalStruvite).
3. Crystals were more often detected in patients with urinary tract infections than those without, (23.3%, *P*=0.03).
4. Bacteria were isolated in 32% of patients (404/1262). They belonged mainly to the *Escherichia* (9.6%; 121 cases), *Staphylococcus* (7%; 89 cases), *Streptococcus* (5%; 63 cases) and *Klebsiella* (3%; 38 cases) genera.
5. Urinary tract infections were common in patients over 60 years old and in those with alkaline urine pH. Women were more likely to be infected.

Implications for future practices and policies

Further studies should evaluate the relationship between bacteria and kidney stones in lithiasis patients in Gabon.

INTRODUCTION

Crystalluria is a phenomenon commonly encountered in about 10% of the population. Generally, it begins with urine supersaturation followed by crystal formation and retention in the absence of inhibitors of crystallogenesis [1, 2]. Different crystals types have been reported, including calcium oxalate, calcium phosphate, ammonium magnesium phosphate or struvite, ammonium phosphate, uric acid, cystine, 2,8-dihydroxyadenine, N-acetyl sulfamethoxazole, and xanthine [2–6]. Studies have reported that crystalluria could be an index of calculus or a lithiasis marker, and its persistence represents a major risk for the formation of lithiasis, conferring a clinical relevance to crystalluria when associated with urine acidity and alkalinity [7]. The main causes of urinary crystallogenesis have been reported. These include the absence of inhibitors filtered through the glomeruli or produced locally by tubular cells [8, 9]. These inhibitors are mainly magnesium, citrate and pyrophosphate, preventing crystal formation and growth, aggregation and/or adhesion to the tubular epithelium [8, 9]. In addition, macromolecules such as bikunin, matrix GLA protein, osteopontin, Tamm-Horsfall protein, or urinary fragment 1 of prothrombin, can stop urinary crystallogenesis by promoting renal elimination, including oxalate, calcium, phosphate and urate, which enables crystalluria by increasing, for example, the calcium oxalate or calcium phosphate insoluble precipitation rate [3, 8–11]. These promoters, one of the most common of which is oxalate, have endogenous and exogenous origins [12]. Interestingly, several studies have reported important relationships between crystalluria promoters and bacteria isolated in urine, suggesting that bacteria could promote crystal formation [12, 13]. In 2013 and 2014, Nacaroglu and Balestracci teams, respectively, argued that idiopathic hyper calcinuria in children increased the rate of urinary tract infections. The bacteria involved belong to the *Escherichia*, *Staphylococcus*, *Klebsiella*, *Proteus*, *Pseudomonas*, *Enterobacter* and *Enterococcus* genera [4–6, 13–15]. These studies added that these bacteria, whether or not due to their urealytic properties and sometimes involving FimH gene, are linked to specific crystals [5, 13, 15, 16]. In 1999 and 2000, struvite crystal was reported to be positively correlated with *Proteus* than with *Providencia*, *Klebsiella*, *Morganella* and *Staphylococcus* [17, 18]. In addition, in 2015, *Enterobacteriaceae*, more specifically *Escherichia coli*, were preferentially isolated in urine with calcium oxalate [16]. These observations testify to a link between crystals and bacteria isolated in the urine during urinary infections [19]. In Gabon, urinary tract infections are common but no studies have yet evaluated the crystals and bacteria usually identified in urine in Libreville, nor explored the link between them [20, 21]. This study aimed to identify the crystals and bacteria commonly found during urinary tract infections and to measure their prevalence, as well as the correlation existing between these crystals and bacteria.

PATIENTS AND METHODS

Study, patients and sample collection

This study was conducted in the Bacteriology Laboratory of the Bacteriology and Virology Department of the Libreville Health Sciences University in Gabon. Overall, 1262 patients (454 male and 808 female), aged between three months to 83 years old, and who presented between 1995 and 2015 for a urine cytobacterial analysis were included. Eligible patients were those whose urine samples were freshly collected in clean, sterile jars under strict aseptic conditions after staying in the bladder for at least four hours.

Ethics statement

This study was approved by the Gabonese national ethics committee under the number PROT No.0057/2022/CNER/P/SG. Written informed consent forms and questionnaires were completed for each patients. For child participants, oral consent was systematically obtained from parents or legal guardians.

Macroscopic analysis

Urine appearance, colour, turbidity, and pellet were assessed. Other urinary parameters such as specific gravity, pH, proteinuria, urobilinogen, bilirubin, ketones, nitrites, leukocytes and glucose were assessed using total urine impregnation with the urine-10 multi-reagent strip (Cypress Diagnostics, Langdorsesteeweg, Belgium). According to the pH levels, urine was divided to acidic (pH<7), neutral (pH=7), and basic (pH>7).

Microscopic analysis and culture

Fresh urine from each patient was inoculated onto Cysteine Lactose Electrolyte Deficient agar medium (CLED) and incubated at 37 °C for between 18 and 24 hours to check purity and urine germ count [22]. The rest was transferred into 5 ml sterile tubes and centrifuged for ten minutes at 2500 rpm using an IEC CL10 centrifuge (Thermo Electron Industries SAS, Chateau-Gontier, France). One part of the sediment was examined microscopically using a DM750 light microscope (Leica Microsystems, Switzerland) to evaluate the presence of red blood cells, leukocytes, bacteria, yeast, *Schistosoma haematobium* eggs and crystals [22]. Crystals were identified as previously reported by Daudon [3]. The remainder was resuspended and inoculated onto D-coccosel, Eosin Methylene Blue (EMB), MacConkey, Chapman, Muller Hilton and Sabouraud Chloramphenicol agar media (bioMérieux, Marcy etoile, France) and incubated at 37 °C for 18 and 24 hours [22].

Bacterial identification

Bacteria were identified using Gram stain, catalase, oxidase, coagulase tests and Api 20 E, Api 20 NE, Api staph, and Api strep strips, as previously reported [23].

Statistical analysis

Data were collected using Microsoft Excel software while statistical analyses were performed using the Epi Info version 7.0.8, Stata 14 and XLSTAT (24) softwares. Statistical significance was considered for a *P* value lower than 0.05.

RESULTS

Patient characteristics

Overall 1262 patients were included. 454 were male and 809 were female, giving a sex ratio (M/F) of 0.56. They were age from three months to 83 years old and were distributed as follows: 0–15 years old (12.9%; 163/1262), 16–60 years old (81%; 1022/1262), and over 60 years (6.1%; 77/1262 subjects) (Fig. 1). **Urine pH**

Urine pH ranged from 4 to 9. Of the 1262 urine samples, 89% were acidic (1129/1262), 6.8% were neutral (86/1262), and 3.7% were basic (47/1262) (Fig. 2). Overall, acidic urines were found significantly more often in females (709/1129; 63%) than in males (420/1129; 37%), with *P* values of 0.006. Also basic urines were found significantly more often in females (39/47; 83%) than in males (8/47; 17%), with *P* values of 0.008. The means of pH were higher in females 5.92±0.76 than in males 5.79±0.65, *P*=0.0013. **Crystals found in urine**

Of the1262 urine sediments analysed, crystals were detected in 249 patients (19.7%). Calcium oxalate and uric acid were the most frequently found crystals in 167 (13.2%) and 32 (2.5%) urine samples, respectively. Cystine was identified in three patients.

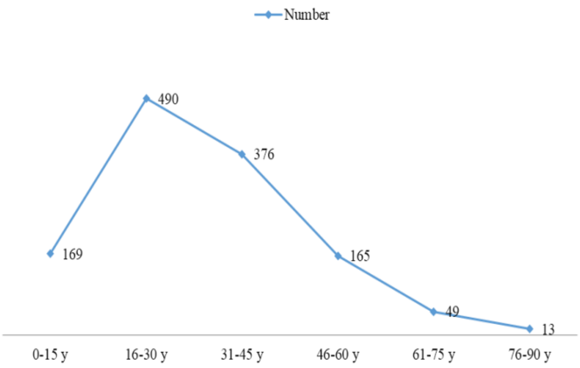

Figure 1. Age distribution of study population

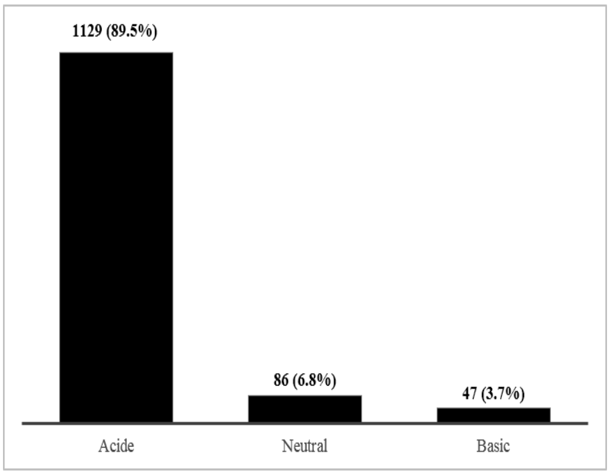

Figure 2. Urine according to pH

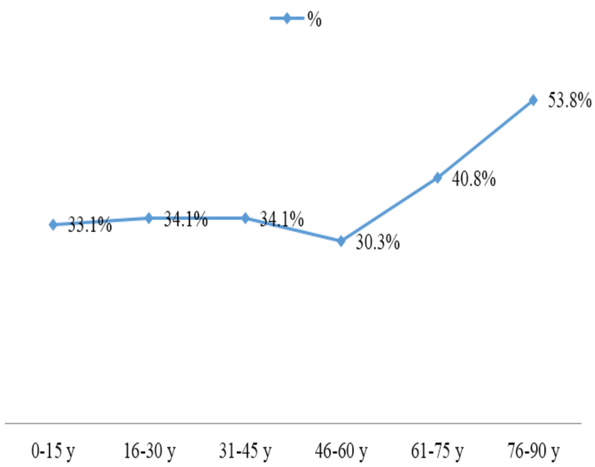

Figure 3. Prevalence of urinary tract infections according to age

In 22 urine samples, two or three crystals coexisted (Table 1): seven had calcium oxalate and uric acid crystals (OxCalAcUr), three had calcium oxalate and amorphous phosphate crystals (OxCalPhosAm), two had struvite and calcium phosphate crystals (StruvitePhosCal), four had calcium oxalate and struvite crystals (OxCalStruvite), one had calcium oxalate and cystine crystals (OxCalCyst), one had struvite and cystine crystals (StruviteCyst), one had uric acid and calcium phosphate crystals (AcUrPhosCal), one had amorphous urate and calcium oxalate crystals (UrAmonOxCal), one had calcium oxalate and calcium phosphate crystals (OxCalPhoscal), and one had calcium oxalate, uric acid and struvite crystals (OxCalAcUrStruvite).

Crystal profiles according to age and sex

With the exception of calcium oxalate and uric acid, the other crystals were heterogeneously distributed across the different age groups (Table 1). The prevalence of crystals was greater in patients between the ages of 15 to 59 years old. Crystal distribution according to sex revealed a higher prevalence in males (21.1%, 96/454) than in females (18.9%, 153/808), but without statistical significance (Figure 3).

Crystals profiles according to pH

The prevalence of crystals in acidic, neutral and basic urine was 19.8% (224/1129), 18.6% (16/86) and 19.1% (9/47), respectively (Table 2). Uric acid, struvite, amorphous urate and ammonium urate crystals were involved only in acidic and neutral urine, while cystine was identified in three acidic urine samples

Table 1. Crystal distribution according to age N(%)

Crystal	Population (n=1262)	0–14 years old (n=163)	15–59 years old (n=1022)	≥60 years old (n=77)
Calcium oxalate	167 (13.2)	15 (9.2)	143 (14)	9 (11.7)
Uric acid	32 (2.5)	8 (4.9)	21 (2.1)	3 (3.9)
Calcium phosphate	13 (1)	3 (1.8)	10 (1)	0 (0)
Struvite	8 (0.6)	0 (0)	8 (0.8)	0 (0)
OxCalAcUr	7 (0.5)	0 (0)	5 (0.5)	2 (2.6)
OxCalStruvite	4 (0.3)	1 (0.6)	2 (0.2)	1 (1.3)
OxCalPhosAm	3 (0.2)	0 (0)	3 (0.3)	0 (0)
Amorphous urate	2 (0.1)	0 (0)	2 (0.2)	0 (0)
StruvitePhosCal	2 (0.1)	0 (0)	2 (0.2)	0 (0)
Ammonium urate	2 (0.1)	0 (0)	2 (0.2)	0 (0)
Amorphous phosphate	1 (0.07)	0 (0)	1 (0.1)	0 (0)
Cystine	1 (0.07)	0 (0)	1 (0.1)	0 (0)
Calcium carbonate	1 (0.07)	0 (0)	1 (0.1)	0 (0)
OxCalAcUrStruvite	1 (0.07)	0 (0)	1 (0.1)	0 (0)
OxCalCyst	1 (0.07)	0 (0)	1 (0.1)	0 (0)
StruviteCyst	1 (0.07)	0 (0)	1 (0.1)	0 (0)
AcUrPhosCal	1 (0.07)	0 (0)	1 (0.1)	0 (0)
UrAmonOxCal	1 (0.07)	0 (0)	1 (0.1)	0 (0)
OxCalPhoscal	1 (0.07)	0 (0)	1 (0.1)	0 (0)
Total	**249 (19.7)**	**27 (16.6)**	**207 (20.2)**	**15 (19.5)**

Table 2. Crystal distribution according to pH N(%)

Crystal	Population (n=1262)	acidic pH (n=1129)	neutral pH (n=86)	basic pH (n=47)
Calcium oxalate	167 (13.2)	153 (13.6)	9 (10.5)	5 (10.6)
Uric acid	32 (2.5)	31 (2.7)	1 (1.2)	0 (0)
Calcium phosphate	13 (1)	8 (0.7)	2 (2.3)	3 (6.4)
Struvite	8 (0.6)	6 (0.5)	2 (2.3)	0 (0)
OxCalAcUr	7 (0.5)	7 (0.6)	0 (0)	0 (0)
OxCalStruvite	4 (0.3)	4 (0.4)	0 (0)	0 (0)
OxCalPhosAm	3 (0.2)	1 (0.08)	1 (1.2)	1 (2.1)
Amorphous phosphate	1 (0.07)	1 (0.08)	0 (0)	0 (0)
Cystine	1 (0.07)	1 (0.08)	0 (0)	0 (0)
Amorphous urate	2 (0.1)	2 (0.2)	0 (0)	0 (0)
Ammonium urate	2 (0.1)	1 (0.08)	1 (1.2)	0 (0)
StruvitePhosCal	2 (0.1)	2 (0.2)	0 (0)	0 (0)
Calcium carbonate	1 (0.07)	1 (0.08)	0 (0)	0 (0)
OxCalAcUrStruvite	1 (0.07)	1 (0.08)	0 (0)	0 (0)
OxCalCyst	1 (0.07)	1 (0.08)	0 (0)	0 (0)
StruviteCyst	1 (0.07)	1 (0.08)	0 (0)	0 (0)
AcUrPhosCal	1 (0.07)	1 (0.08)	0 (0)	0 (0)
UrAmonOxCal	1 (0.07)	1 (0.08)	0 (0)	0 (0)
OxCalPhosCal	1 (0.07)	1 (0.08)	0 (0)	0 (0)
Total	**249 (19.7)**	**224 (19.8)**	**16 (18.6)**	**9 (19.1)**

Table 3. Crystal distribution in patients

Crystal	Population (n=1262)	Patient with UTI (n=404)	Patient without UTI (n=858)	P
Calcium oxalate	167 (13.2)	57 (14.1%)	110 (12.8%)	0.5
Uric acid	32 (2.5)	15 (3.7%)	17 (2%)	0.08
Calcium phosphate	13 (1)	4 (1%)	9 (1%)	1
Struvite	8 (0.6)	5 (1.2%)	3 (0.3%)	0.1
OxCalAcUr	7 (0.5)	3 (0.7%)	4 (0.5%)	0.6
OxCalStruvite	4 (0.3)	2 (0.5%)	2 (0.2%)	0.5
OxCalPhosAm	3 (0.2)	1 (0.2%)	2 (0.2%)	1
Amorphous urate	2 (0.1)	2 (0.5%)	0 (0%)	0.1
Ammonium urate	2 (0.1)	1 (0.2%)	1 (0.1%)	0.5
StruvitePhosCal	2 (0.1)	1 (0.2%)	1 (0.1%)	0.5
Amorphous phosphate	1 (0.07)	0 (0%)	1 (0.1%)	1
Cystine	1 (0.07)	0 (0%)	1 (0.1%)	1
Calcium carbonate	1 (0.07)	0 (0%)	1 (0.1%)	1
OxCalAcUrStruvite	1 (0.07)	1 (0.2%)	0 (0%)	1
OxCalCyst	1 (0.07)	1 (0.2%)	0 (0%)	1
StruviteCyst	1 (0.07)	1 (0.2%)	0 (0%)	1
AcUrPhosCal	1 (0.07)	0 (0%)	1 (0.1%)	1
UrAmonOxCal	1 (0.07)	0 (0%)	1 (0.1%)	1
OxCalPhosCal	1 (0.07)	0 (0%)	1 (0.1%)	1
Total	**249 (19.7)**	**94 (23.3%)**	**155 (18.1%)**	**0.03**

.

Table 4. Bacteria isolated in patients exhibiting crystalluria

Bacteria	Population n=1262	Patients presenting crystals n=249
Escherichia	121 (9.6)	22 (8.8)
Staphylococcus	89 (7)	22 (8.8)
Streptococcus	63 (5)	12 (4.8)
Klebsiella	38 (3)	13 (5.2)
Enterobacter	24 (1.9)	6 (2.4)
Citrobacter	22 (1.7)	5 (2)
Aeromonas	11 (0.9)	3 (1.2)
Pseudomonas	10 (0.8)	2 (0.8)
Proteus	10 (0.8)	5 (2)
Serratia	8 (0.6)	1 (0.4)
Providencia	4 (0.3)	1 (0.4)
Photobacterium	2 (0.2)	1 (0.4)
Acinetobacter	1 (0.07)	0 (0)
Pasteurella	1 (0.07)	1 (0.4)
Total	**404 (32)**	**94 (37.8)**

Crystal distribution among patients with urinary tract infections

Overall, the prevalence of crystals was higher in infected patients (23.3%, 94/404) than in uninfected patients (18.1%, 155/858), *P*=0.03 (Table 3). Specifically, the prevalence of calcium oxalate, uric acid, struvite and amorphous urate crystals was higher in infected patients.

Pasteurella multocida was found in urine samples containing calcium oxalate crystals (1/185, 0.54%) than in those without (0/1078, 0%), *P*=0.016; *Klebsiella* sp in urine samples containing struvite (2/16, 12.5%) than in those without (36/1247, 2.9%), *P*=0.025; *Klebsiella pneumoniae* in urine samples containing uric acid (3/41, 7.3%) than in those without (12/1222, 1%), *P*<0.01, *Citrobacter* sp was in urine samples containing struvite (2/16, 12.5%) than in those without (20/12547, 1.6%), *P*= 0.001 and *Proteus* in urine samples containing amorphous urate (2/3, 66.7%) than in those without (8/1260, 0.6%), *P*<0.01.

Bacterial profiles

In the 404 patients with urinary tract infections, the burden of infection varied according to age: 33.1% in those aged 0–15, 34.1% in those aged 16–30 and 31–45, 30.3% in those aged 46-60, 40.8% in those aged 61–75, and 53.8% in those aged 76–90, but without statistical significance, *P*=0.166 (Fig 3). In addition, UTIs (urinary tract infections) were lower in males (22%, 100/454) than in females (37.6%, 304/809), *P*<0.001. UTIs increased significantly with pH: 30.6% (345/1129) in acidic, 40.7% (35/86) in neutral and 48.9% (23/47) in basic urines, *P*=0.018.

Escherichia was the main pathogen detected (9.6%; 121/404) followed by *Staphylococcus* (7%; 89/404), *Streptococcus* (5%; 63/404) and *Klebsiella* (3%; 38/404). Among the 249 patients with crystals, 94 presented UTIs. These UTIs were mainly due to the *Escherichia* (8.8%; 22/249), *Staphylococcus* (8.8%; 22/249), *Streptococcus* (4.8%; 12/249) and *Klebsiella* (5.1%; 13/249) genera (Table 4).

DISCUSSION

An understanding of crystals and the bacteria involved in urinary tract infections is of great interest in Gabon, as relevant data are currently scarce. In this study, calcium oxalate crystals were the most common in urine, as previously reported in other countries [2–6, 12]. This predominance should be explain by consumption of a diet which is rich in calcium and oxalate foods, justified by hypercalciuria (daily urinary calcium excretion of over 800 mg) and hyperoxaluria (daily urinary oxalate excretion of more than 400 mg) [25]. Reducing bacterial intestinal oxalate systematically leads to a reduction in the formation of calcium oxalate crystals [12]. The often-reported relationship between calcium oxalate and *Enterobacteriaceae* during urinary tract infections could be an additional reason for its high frequency during urinary tract infections [5, 6]. In addition, some crystals such as urates promote the formation of calcium oxalate through heterogeneous nucleation mechanisms and creating competition for inhibitor sites [3]. After calcium oxalate, uric acid, amorphous phosphate, and struvite crystals were the most common. In contrast, cystine crystals were identified in only three patients, representing a minor risk of lithiasis in the study population. Furthermore, these observations showed that urinary crystals varied in Gabon. Mixtures of crystals were identified in 22 samples. These included OxCalAcUr, OxCalPhosAm, StruvitePhosCal, OxCalStruvite, OxCalAcUrStruvite, OxCalCyst, StruviteCyst, AcUrPhosCal, UrAmonOxCal and OxCalPhoscal. These associations, as well as OxCalStruvite, OxCalAcUr, OxCalPhoscal and UrAmonOxCal, were reported [6, 26]. This phenomenon could be associated with pathophysiological changes and clinical abnormalities in the assessment of renal function [6]. Some crystals were higher in urine samples with specific pH levels. The prevalence of calcium oxalate was 13.6% in acidic urine and 10.6% in pH basic urine. Uric acid, amorphous urate and cystine crystals were found only in acidic urine. Calcium phosphate was greater in alkaline urine (6.4%) than in acidic urine (0.7%). Additionally, amorphous phosphates and amorphous urates were identified in alkaline urine and acid urine, respectively [3]. These observations support previously reported data, pointing to the fact that some crystals exist exclusively in acidic urine and others in alkaline urine [3]. However, this appears not to be absolute because amorphous phosphates and triple phosphates can be identified in slightly acidic urines [3]. The association between crystals and urine pH could be explained by specific precursor precipitation inducing crystallogenesis at specific pH levels, when crystalluria inhibitors such as magnesium, citrate, pyrophosphate, bikunin, matrix GLA protein, osteopontin, and Tamm-Horsfall protein are deficient [3, 8–11, 27]. Crystals were found more often in patients over the age of 15, while no statistical difference was observed in their distribution according to sex. Bacteriuria was significantly higher in patients exhibiting crystalluria 23.3% than in those without crystalluria 18.1%. This observation supports studies evoking a link between bacteria and crystals [5, 6, 13, 15, 16, 18, 26, 28]. It has been reported that struvite is positively correlated to *Proteus* and no to *Providencia*, *Klebsiella*, *Morganella* and *Staphylococcus* genera [17, 18]. In 2015, it was shown that *Escherichia coli* was more often isolated in urine containing calcium oxalate crystals [16]. The bacteria coexisting with crystals were mainly *Escherichia* spp, *Staphylococcus* spp, *Streptococcus* spp, *Klebsiella* spp and *Proteus* spp. *E. coli,* use aggregation mechanisms for crystal synthesis. Other bacteria, including *Klebsiella*, *Proteus* and *Enterobacter* spp., take advantage of their ability to alkalise urine through their urealytic properties, allowing them to convert urea to ammonia. That results in the precipitation and subsequent formation of urine crystals. Other authors have pointed out that bacteria produce citrate lyase, inducing a reduction in urinary citrate load, urine saturation and crystal formation [29]. The average urine citrate was two times lower in 17 patients with a positive urine culture than in 30 with a negative urine culture [29]. Of the bacteria isolated, *E. coli* was the most significant followed by *Staphylococcus* spp, *Streptococcus* spp, *Klebsiella* spp, *Enterobacter* spp, and *Proteus* spp [11, 20, 22, 30–34]. The bacteria identified in this study remain the same than those usually reported during urinary tract infections in Africa [11, 20, 22, 30–34]. The high prevalence of *E. coli* could be related to factors favouring its persistence, adherence, colonisation, and invasion in the urinary tract, and it ability to resist several antibiotics [19, 20, 33]. The prevalence of urinary tract infections identified in this study (32%) remains higher than those previously reported in 2019 in Libreville (25.4%) and 2021 in Franceville (29.2%) [20, 33]. This difference could be due to the epidemiological profile variations in uropathogenic bacteria according region [35].

CONCLUSION

Finally, crystalluria and bacterial UTIs, although previously underestimated, are undoubtedly common in Gabon and often coexist in patients. There is also an influence of pH on crystals and bacterial distribution in the urine, indicating that alkaline pH and crystals are suggestive of UTIs and could guide their diagnosis. Knowledge of the local epidemiology of UTIs and their evolution remains crucial in terms of identifying an effective first-line antibiotic therapy adapted to each region. Further studies should be conducted to evaluate the relationship between bacteria and kidney stones in lithiasis patients in Gabon.

Limitation

Some limitations of this study are the fact that, fungal result were not considered as well as uncultivable bacteria and virus. That could help to better understand the causes of some urinary tract infections in which bacteria were not found.

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