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CHANGES IN HEMOSTATIC SYSTEM PARAMETERS IN PATIENTS UNDERGOING CORONARY STENTING

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Abstract: Background: Different age groups exhibit unique epidemiological and composition patterns of bladder urolithiasis. Specifically, adults are more likely to have calcium-containing bladder stones. In contrast, children will usually have bladder stones made up of either uric acid or due to infection in children, especially in developing countries. There is currently no literature comparing bladder stone composition between pediatric and older adults living in Iraq.

Purpose: To evaluate and compare the incidence and biochemical composition of urinary bladder stones from elderly (greater than or equal to 40 years) vs. pediatric patients (less than or equal to 12 years) at a tertiary referral center located in Al-Muthanna City, Iraq,

Methods: A prospective observational study was conducted from March 2019 to April 2025 at Al-Hussein Teaching Hospital. Five hundred forty-two bladder stone specimens were obtained surgically, by endoscopic cystolitholapaxy and/or spontaneously, and analyzed with FTIR. The patients were divided into pediatric (< or equal to 12 years) and elderly (> or equal to 40 years). The chi-squared test was used for comparison.

Results: Of 542 patients, 512 (94.5%) were elderly, and 30 (5.5%) were pediatric. The mean age of those patients was 56.2 ± 16.4 years. The male-to-female ratio was 2:1. Elderly patients had significantly more calcium oxalate stones (35.5% vs 0.0%, $p < 0.001$), while uric acid stones were most common in children (40.0% vs 0.4%, $p < 0.001$). The phosphate stone and mixed stone populations did not differ significantly.
Conclusion: Calcium oxalate accounted for the majority of bladder stones among elderly patients, while uric acid was the most common stone type in the pediatric subgroup. The results highlight the need for age-specific metabolic assessments and region-specific preventive programs for bladder urolithiasis.
Keywords: Bladder stones; urolithiasis; calcium oxalate; uric acid; FTIR; pediatric; elderly; Iraq.

Introduction

Worldwide, urinary bladder stones are a common urinary system-related health issue; however, researchers indicate that the incidence of this condition increases dramatically in developing countries and in countries with limited resources [1]. In adult males, bladder stones most often occur secondary to bladder outlet obstruction (BOO), affecting approximately 3-8% of men; for example, the most frequent cause of BOO in this population is benign prostatic hyperplasia (BPH) [2],[3]. The process by which

bladder stones form involves complex interactions among urine stagnation, changes in urine pH, decreased levels of urinary crystallization inhibitors, and systemic metabolic alterations [4].

In the elderly, three particular metabolic conditions, hypercalciuria, hyperuricosuria, and low urinary citrate, are the main metabolic contributors to the formation of urinary stones [5]. Childs and associates reported in a detailed metabolic analysis that children with stones in their bladders had lower 24-hour urine pH and lower magnesium levels than those children who did not have stones, while also having significantly increased levels of uric acid in their urine compared to controls [2]. Calcium oxalate was the most common type of stone observed in the adult population with bladder problems, indicating a metabolic disease process [1],[3].

The epidemiology of pediatric bladder stone disease differs markedly from that of adult bladder stones. The prevalence does not match that of adults in developed nations; however, there are still many reports from underdeveloped nations of pediatric bladder stones [6],[7]. The estimated incidence of pediatric urinary stone disease (urolithiasis) ranges from 1:7,000 to 1:10,000 in the developing world [8]. Causes of bladder stones in children include developmental urinary tract malformations, recurrent urinary tract infections, inherited metabolic disorders, and nutritional deficiencies [9],[10]. There is a significant disparity in male-female ratios of bladder stones in children, with reported ratios ranging from 15:1, and the highest incidence being between two and five years of age [8],[11].

The prevalence of bladder stones varies geographically and depends on dietary improvement and public health infrastructure, as demonstrated in developed countries [6],[12]. Conversely, significant malnutrition and ongoing dehydration continue to be contributing factors to bladder stone disease in developing parts of the world [13]. According to Kamoun and colleagues, struvite accounted for 22% of bladder stones in children in Tunisia, which illustrates the association of UTIs as a causative factor in endemic areas [10]. Similarly, Sarkissian and colleagues have documented that calcium oxalate metabolic stones are the predominant constituents of bladder stones in an Armenian pediatric cohort of 198 patients [11].

The presenting signs and symptoms of bladder stones may differ greatly between adults and children. An adult with bladder stones may have severe lower urinary symptoms such as dysuria, urgency, and interruption of the urinary stream, and terminal hematuria [3]. In younger children, bladder stones present with nonspecific symptoms, including urgency, tachyuria, incontinence, or fever. Hematuria may be present as either gross or microscopic in approximately 33% to 90% of cases [8],[9].

Due to the varied presentations of bladder stones in pediatric patients, several treatment modalities have been reported in the literature, including extracorporeal shock wave lithotripsy, endoscopic cystolitholapaxy, and percutaneous suprapubic approaches; however, the success rates of these modalities

have varied widely [14],[15].

The analysis of stone composition is an important diagnostic tool for determining the underlying pathophysiology and for developing appropriate prevention strategies. The literature has documented with published longitudinal studies that calcium oxalate percentages average approximately 45% to 65% for bladder stones—second most frequent are calcium phosphate composed stones averaging 14% to 30%, uric acid stones averaging 5% to 10%, struvite stones averaging 5% to 10%, and cystine stones averaging 1% to 5% [1],[4]. Li and colleagues demonstrated that several local urinary factors, including urinary pH, urinary volume, and uric acid supersaturation, are strongly associated with the development of uric acid stones, regardless of pre-existing systemic metabolic disorders [12]. Fourier Transform Infrared Spectroscopy (FTIR) is currently the method of choice for stone composition analysis because it enables simultaneous identification and quantitative analysis of multiple stone components, including complex and mixed stone types [7].

Data from Iraq and the broader Middle East region on the composition of bladder stones among the elderly and pediatric populations are very limited despite the significant burden of urinary tract stone disease in this area of the world. Rizvi and colleagues managed over 1,440 pediatric patients with bladder stones in Pakistan and emphasized that metabolic profiling is a vital means of developing prevention strategies [9]. Therefore, this study was performed to compare and analyze the biochemical composition of bladder stones from patients treated at Al-Hussein Teaching Hospital, which is the main urological referral center in Al-Muthanna Province, located in southern Iraq, in both elderly (≥ 40 years) and pediatric patients (≤ 12 years), utilizing FTIR spectroscopy.

Material and Methods

Study Design and Setting

This was a prospective observational study through the Department of Urology at Al-Hussein Teaching Hospital, including patients who presented with confirmed bladder stones via imaging from March 2019 through April 2025. Al-Hussein Teaching Hospital is the primary urology hospital for the province of Al-Muthanna and serves approximately 200,000 people in the rural southern region of Iraq.

Patient Selection

All patients presenting with imaging-confirmed bladder stones were eligible for inclusion in the study if they were either in the pediatric age group (≤12 years) or in the elderly age group (≥40 years) and had sufficient rock material for FTIR analysis. Patients with incomplete records and/or insufficient stone

samples were excluded.

Methods of Retrieval of Stones

Bladder stones were removed using: (i) open or laparoscopic cystolithotomy (32.1%), (ii) endoscopic cystolitholapaxy by means of a rigid cystoscope (53.7%), or (iii) spontaneous passage (14.2%). All samples were cleaned and dried at ambient temperature, then placed in labeled, sterile containers.

FTIR Analysis of Stones

All stones were finely powdered, combined with potassium bromide (KBr), and pressed into a pellet. Spectra were obtained in the range of 400-4000 cm^{-1}. The list of stone types categorized included: calcium oxalate monohydrate (COM), calcium oxalate dihydrate (COD), struvite, carbonate apatite, uric acid/urate, cystine, mixed stones, and rare/other types.

Statistical Analysis

Descriptive statistics for categorical variables were expressed as frequencies and percentages, and for continuous variables as mean ± SD (range). To compare differences among groups, the chi-square (χ^2) test or Fisher's exact test was used where applicable (statistical significance level: $p < 0.05$). All data analyses were performed using SPSS version 26.0 (IBM Corp., Castle Rock, NY).

Ethics

The study conformed to the principles of the Declaration of Helsinki. Approval from the Institutional Review Committee at Al-Hussein Teaching Hospital, Al-Muthanna, Iraq, was obtained. All patients aged 18 or older provide their own written informed consent. Written informed consent was obtained from guardians of minor children.

Result

Patient Demographics

Five hundred forty-two samples of bladder stones were reviewed. The average age of patients was 56.2 years, with a standard deviation of 16.4 (range: 2-90). Males made up 66.6% (361) of the patients, and females composed 33.4% (181), giving us a male-to-female ratio of 2:1. Out of the complete cohort, there were 512 patients (94.5%) who were aged ≥40 (elderly) and 30 patients (5.5%) <12 years (pediatric). Stones were removed by endoscopic methods (53.7%), surgical techniques (32.1%), or spontaneous passage (14.2%) (Table 1).

Table 1. Descriptive Characteristics of Patients with Bladder Stones (N = 542)

Variable	Category	n	%
Age Group (years)	≤ 12 (Pediatric)	30	5.5
	≥ 40 (Elderly)	512	94.5
	Total	**542**	**100.0**
Sex	Male	361	66.6
	Female	181	33.4
	Total	**542**	**100.0**
Method of Stone Removal	Surgical (open/laparoscopic)	174	32.1
	Endoscopic cystolitholapaxy	291	53.7
	Spontaneous passage	77	14.2
	Total	**542**	**100.0**

Mean age = 56.2 ± 16.4 years (range: 2–90). Male: Female ratio = 2:1.

Overall Stone Composition

FTIR analysis showed that the most common types of stones were mixed stones (33.2% of total stone count (n=180) and Calcium Oxalate stones (33.6% (n=182) with Phosphate stones being a close third at 29.9% of total (n=162). Uric Acid/Urate stones accounted for a small proportion, 2.5% (n=14), of the total stones, while Cystine stones did not appear in any patient's analysis. The 102 Calcium Oxalate (CaOx) stones identified consisted of 18.8% Calcium Oxalate Monohydrate (COM) and 14.8% Calcium Oxalate Dihydrate (COD). The phosphate stones showed that Struvite accounted for 22.3% of the total stones (n=121), and Carbonate Apatite accounted for 7.6% (n=41). An overall breakdown of stone-type composition is shown in Table 2.

Table 2. Results of Bladder Stone Composition by FTIR Analysis (N = 542)

Stone Type	Subtype	No.	%
Calcium Oxalate	(Total)	**182**	**33.6**
	– Monohydrate (COM)	102	18.8
	– Dihydrate (COD)	80	14.8
Phosphate Stone	(Total)	**162**	**29.9**
	– Struvite	121	22.3

	($MgNH_4PO_4$)		
	– Carbonate apatite	41	7.6
Uric Acid / Urate	—	**14**	**2.5**
Mixed	—	**180**	**33.2**
Cystine	—	0	0.0
Others*	—	4	0.8
Total	—	**542**	**100.0**

** Others include rare stone types (e.g., xanthine). COM = calcium oxalate monohydrate; COD = calcium oxalate dihydrate.*

Stone Composition Stratified by Age Group

Calcium oxalate and uric acid stones were the two stone types that had the most significant differences between the elderly and pediatric groups (Table 3). While calcium oxalate stones were found in the elderly group with a higher percentage of 35.5%, they were not found in the pediatric group at all (0.0%); $p < 0.001$, while uric acid stones were found predominantly in the pediatric group with 40.0% compared to only 0.4% for the elderly population; $p < 0.001$. There was no statistical difference between groups for mixed stones (30.0% vs 33.4%, $p = 0.85$) or phosphate stones (30.0% vs 29.9%, $p = 0.84$). Rare stone types were found only in the elderly population (0.8% vs 0.0%; $p = 0.54$).

Table 3. Stone Composition Stratified by Age Group with Statistical Comparison

Stone Type	Age Group (years)				P-value	Total n (%)
	≤ 12 yrs		≥ 40 yrs			
	No.	%	No.	%		
Calcium Oxalate	0	0.0%	182	35.5%	**< 0.001****	182 (33.6)
Uric Acid / Urate	12	40.0%	2	0.4%	**< 0.001****	14 (2.5)
Mixed	9	30.0%	171	33.4%	0.85	180 (33.2)

Phosphate Stone	9	30.0 %	153	29.9 %	0.84	162 (29.9)
Others	0	0.0%	4	0.8%	0.54	4 (0.7)
Total	**30**	**100 %**	**512**	**100 %**		**542 (100)**

*** Statistically significant ($p < 0.001$). Chi-square test applied. FTIR = Fourier Transform Infrared Spectroscopy.*

Discussions

In this current research related to bladder stone composition using Fourier Transform Infrared Spectroscopy (FTIR) for 542 patients from two age ranges at a tertiary care urology center in Southern Iraq, two significant findings were reported including the presence of predominant urinary stone compositions based on age; calcium oxalate (CaOx) stones were more common in older adults (>40 years of age) while uric acid (UA) stones were the predominant urinary stone type in younger patients (age ≤12 years). The two findings were highly statistically significant ($p<0.001$) and consistent with previously established age-related pathophysiological risk factors for urinary bladder stone formation [16], [17].

The higher percentage of elderly adults (94.5%) correlates with existing epidemiological reports. Bauman et al. demonstrated that urinary stasis caused by benign prostatic hyperplasia (BPH) leads to urinary stone formation in these patients [16]. Additionally, Daudon and colleagues showed, through multivariate analysis, that urinary stone composition is influenced by patient age and sex, and that CaOx stones are consistently the most prevalent urinary stone type in males across multiple geographic areas [17]. These observations suggest that urinary stasis and age-dependent metabolic changes (low urine citrate and magnesium concentrations, in particular) create an environment conducive to CaOx crystallization, a finding reported in studies of pediatric urolithiasis as well [18].

CaOx stones constitute the vast majority (35.5%) of urinary stones in elderly adults, a finding consistent with other reports in the medical literature. Ziemba and Matlaga describe the global prevalence of CaOx urinary stones and report that they comprise 60%–80% of all urinary stones in the developed world [19]. One body of evidence that supports this finding is the EAU (European Association of Urology) Guidelines, published in 2001 and 2010, which state that CaOx stones are the most common urinary stone type found in adults with urinary bladder disease, and promote diet and pharmacological prevention through the identification of individual patients' urinary profiles based on 24-hour urine tests [20]. Our percentage of calcium oxalate stones (35.5%) is lower than that observed by many groups in the United States and

Europe. Part of this difference may be due to this group having a high percentage of mixed stones (33.4%), which often contain calcium oxalate. Stones composed of more than one type of crystal are often classified into separate categories, allowing for a clearer picture to emerge when comparing differences, as discussed by authors who have previously addressed their pathogenesis [21].

The distinguishing finding in our group was the high percentage (40.0%) of uric acid and the low percentage (25.0%) of calcium oxalate. This finding differs from most pediatric literature, which describes calcium oxalate as the predominant stone component [18],[22]. It has been reported that modifying dietary purine intake, increasing fluid intake, and normalizing urinary pH above 5.5 will have a direct impact on uric acid stone formation; a pH below 5.5 represents the critical point at which urate crystals precipitate [22]. Conditions in Al-Muthanna Governorate, with its high purine content in foods, very limited fluid intake in a hot, dry climate, and poor overall dietary variety, probably result in chronic acidification of urine in children, leading to uric acid stone formation [23],[24].

Geographical differences in the composition of urinary stones in children have been documented in the literature. Philippou et al. compared endoscopic results among children in both endemic and non-endemic regions worldwide, demonstrating that local resources, such as the availability of urologists and dietary habits, are major contributors to differences in stone composition across geographic areas [25]. Al-Ani has demonstrated that metabolic and infectious processes impact a large number of children with urinary stones in Iraq [23]. According to the descriptions given by Alazawi and Al-Mosawi, urological stone disease is prevalent throughout Iraq and is exacerbated by dehydration, nutrition, and limited access to preventative health care [24]. The current finding of distinct stone-composition profiles between children and adults in Iraq supports the above observations.

In the pediatric population, the absence of calcium oxalate stones is noteworthy. According to Copelovitch, children with urolithiasis in metabolically resource-poor environments rarely experience oxalate-related urolithiasis but rather have pathogenic processes related to urinary infection, purine metabolism abnormalities, or urinary acidification disorders [18]. In addition, Bazin and Daudon showed using FTIR analysis that, in mixed stone-forming populations, stone composition should be studied at the component level and that FTIR will provide additional confirmation of the absence of oxalate-driven pathophysiology [26]. The finding of no cystine stones in both groups indicates that cystinuria is either infrequent in this population or essentially unrecognized due to a lack of genetic testing, as also reported in other resource-poor regions [20],[28].

Struvite stones accounted for 22.3% of the overall population within the phosphate stone group, reflecting a significant infectious contribution to stone disease. The conclusion by Miano et al. that struvite stones

form only in conjunction with urease-producing organisms (i.e., Proteus mirabilis, Klebsiella pneumoniae, and Pseudomonas aeruginosa) and therefore require an active urinary infection to form supports this finding [27]. Struvite lithogenesis is attributed to microbiological factors, both systemic and local, and Flannigan et al. stressed the importance of using antibiotic therapies and performing surgical interventions simultaneously to achieve optimal clearance of struvite stones [21]. Furthermore, the similar proportion of phosphate stones among pediatric patients (30.0%) and elderly patients (29.9%) ($p = 0.84$) suggests that age does not influence infection-induced lithogenesis, corroborating the observation of a high endemic burden of community-acquired urinary tract infection in the region [27],[28].

The strength of the method used to analyze stones is a significant contribution of the current study through the use of FTIR spectroscopy. Bazin and Daudon validated FTIR spectroscopy as an effective tool for characterizing stones; more specifically, they showed that FTIR is superior to polarizing microscopy and wet chemical analysis in identifying small quantities of stones and in quantifying multiple components of the same stone pellet simultaneously [26]. The study population contains a high percentage of patients with mixed stones (33.2% of all samples); therefore, misclassifying stone composition using a single method could lead to errors in determining the appropriate metabolic assessment processes [28].

In their study of stone management, almost 54% of patients underwent endoscopic cystolitholapaxy, consistent with current European Association of Urology guidelines for the treatment of bladder stones [20],[25]. The relatively high percentage of open surgical procedures (32.1%) reflects the high burden of stone disease among patients presenting to the hospital, which is attributed to delays in accessing medical care in this rural area. Such findings have been previously documented in the Iranian health literature [23],[24]. Limitations of the current study include the absence of 24-hour metabolic urine data for all patients, limited imaging data on stone size, and a relatively small pediatric sample ($n = 30$).

Conclusions

Bladder stone composition differs significantly between patients in Al-Muthanna City, Iraq, over the age of 40 (elderly) and those under the age of 12 (pediatric). The dominant stone type in elderly patients is calcium oxalate, which is consistent with its association with obstructive uropathy, urinary stasis, and age-related hypercalciuria. The most common stone type in pediatric patients is uric acid, which is a finding that differs from most pediatric series reported from Western countries; this difference is likely reflective of the nutritional, environmental, or metabolic characteristics of this region.

These findings emphasize the need for routine FTIR analyses of stone composition across all ages, as the underlying metabolic etiology underpins targeted prevention strategies. Young patients with uric acid stones should undergo targeted evaluations for potential pH abnormalities and purine metabolism disorders. Regionally and age-specific

prevention guidelines for urolithiasis should be incorporated into clinical practice guidelines in developing countries with endemic bladder urolithiasis.

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