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Original Article

CLINICAL CHARACTERISTICS AND METABOLIC RISK FACTORS IN PEDIATRIC UROLITHIASIS: A 6-YEAR RETROSPECTIVE ANALYSIS

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ABSTRACT

Introduction: Pediatric urinary stone disease is an increasingly common health problem in children and carries a risk of recurrence. Identifying the underlying metabolic abnormalities is crucial for effective treatment and prevention.

Methods: Pediatric patients diagnosed with urinary stone disease and admitted to our hospital between 2018 and 2024 were retrospectively evaluated. Clinical data, stone localization and type, as well as metabolic parameters, were assessed through 24-hour urine analyses.

Results: A total of 91 patients (59 males, 32 females; mean age: 10.6 years) were included. Renal stones were the most common (75.8%). At least one metabolic abnormality was found in 67.8% of cases, with hypercalciuria (30.8%), hyperoxaluria (17.6%), and hypomagnesuria (11.0%) being the most frequent.

Conclusion: In pediatric stone disease, metabolic evaluation is crucial for identifying underlying disorders and preventing recurrence.

Keywords: Pediatric, urolithiasis, metabolic abnormalities, hypercalciuria, stone disease

INTRODUCTION

Urolithiasis is traditionally considered a condition of adulthood; however, its incidence in children has increased in recent years. In pediatric cases, the age at onset, clinical presentation, and underlying causes differ significantly from those seen in adults (1–3). Although the reported incidence in the pediatric population is around 2%, recent studies have shown a rising trend, especially in children under the age of 15 (3) . In endemic areas such as Türkiye, this rate may reach up to 17% (4,5).

Pediatric urolithiasis is a multifactorial disease in which metabolic and anatomical abnormalities play a major role in pathogenesis. Although less common in children, recurrence rates are higher than in adults. Therefore, metabolic evaluation is an important step in assessing and managing the risk of recurrence (1,6,7).

The American Urological Association (AUA) recommends metabolic evaluation for all pediatric patients following diagnosis. This assessment aims to detect treatable metabolic abnormalities, prevent recurrence, and identify possible genetic disorders. Earlier studies reported hypercalciuria as the most common metabolic abnormality; however, more recent research suggests that hypocitraturia may now be more frequent (8–13).

The aim of this study was to evaluate metabolic abnormalities in pediatric patients diagnosed with urolithiasis who underwent intervention, and to determine the types of metabolic disorders identified.

METHODS

This retrospective study included pediatric patients who were diagnosed with urolithiasis and received treatment between 2018 and 2024. Patients with complete medical records were evaluated according to age, clinical symptoms, stone location, stone size, number of urinary tract infections (UTIs), and treatment method. The diagnosis of urolithiasis was based on clinical findings and confirmed by ultrasonography (USG) and/or computed tomography (CT). Follow-up consisted of serial USG examinations. Remission was defined as the absence of symptoms and no detectable stones on imaging.

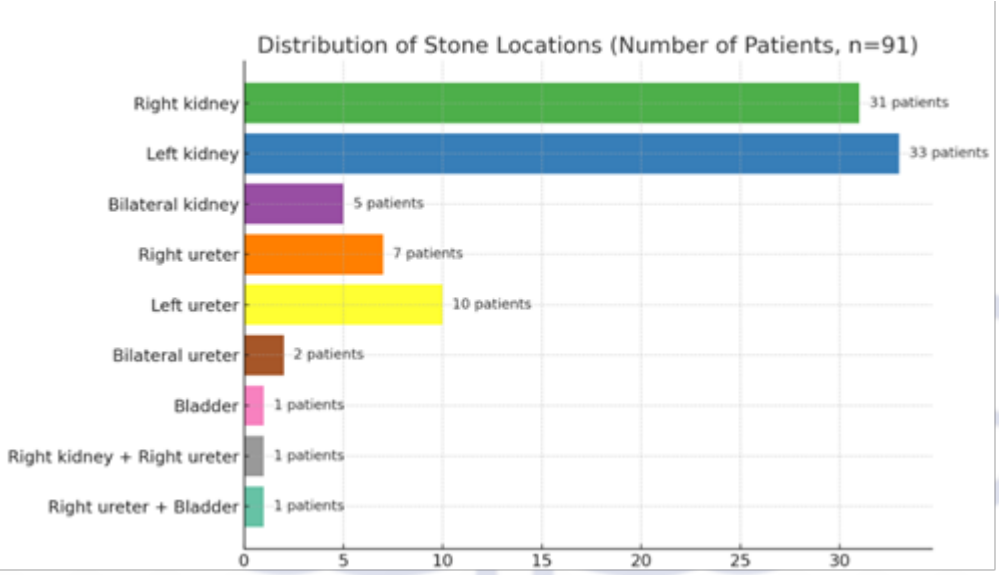
UTI frequency was evaluated in all patients. UTI was defined by the presence of pyuria (>5 white blood cells per high-power field) and a positive urine culture, where significant growth was defined as $\geq 10^5$ colony-forming units per milliliter (CFU/mL) of a single microorganism in midstream clean-catch or catheterized urine samples.

Metabolic evaluation was performed using 24-hour urine analysis and included the investigation of six major abnormalities: hypercalciuria, hypocitraturia, cystinuria, hyperoxaluria, hyperuricosuria, and hyperphosphaturia. Hypercalciuria was defined as a urinary calcium excretion greater than 4 mg/kg/day or a calcium-to-creatinine ratio exceeding 0.8 mg/mg in infants

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Figure 1. Distribution of Stone Locations



aged 0–6 months, 0.6 mg/mg in those aged 7–12 months, and 0.2 mg/mg in children aged 1–18 years. Cystinuria was diagnosed when 24-hour urinary cystine excretion exceeded 0.5 mmol/1.73 m² or the spot urine cystine-to-creatinine ratio was above 35 mmol/mol. Citrate excretion was considered normal if it was greater than 1.6 mmol/1.73 m²/day or if the citrate-to-creatinine ratio was over 0.1 mol/mol. Normal tubular phosphate reabsorption was defined as 4.1 ± 0.6 mg/dL per estimated glomerular filtration rate (eGFR). Oxalate and uric acid levels were accepted as normal if daily excretion was below 0.5 mmol/1.73 m² and 0.56 mg/dL/eGFR, respectively.

Ethical Considerations

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical approval was obtained from the institutional ethics committee with Decision No. 408.

Statistical Analysis

The statistical evaluation in this study was intentionally confined to descriptive analysis, as the primary aim was to characterize the clinical spectrum and metabolic patterns of pediatric urolithiasis rather than to test predefined hypotheses. Continuous variables were summarized through measures of central tendency and range, while categorical findings were expressed as numerical counts and proportions to reflect their distribution within the cohort. Given the observational and noncomparative design of the study, inferential statistics and predictive modeling were not applied.

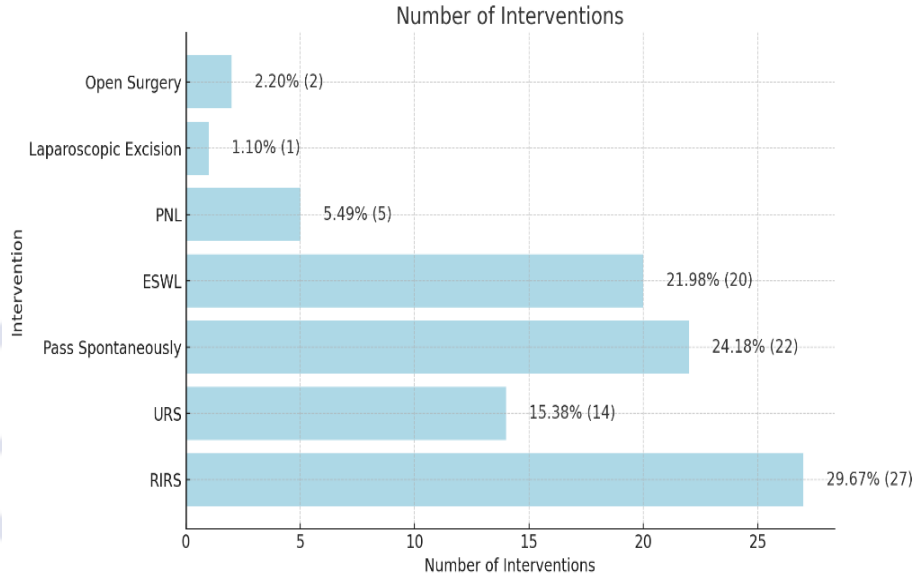
RESULTS

A total of 91 pediatric patients were included, 59 (64.8%) males and 32 (35.2%) females, with a mean age of 10.6 years (range: 19 months–17 years). In these patients, 101 urinary tract stones were identified. Renal stones were the most common, observed in 69 patients (75.8%): 31 in the right kidney, 33 in the left, and 5

Table 1. Patients Symptoms

	Symptom	Number of Patients	Percentage (%)
1	Flank pain	47	51.65
2	Fever	22	24.18
3	Hematuria	14	15.38
4	Vomiting	9	9.89
5	Urinary incontinence	5	5.49

Figure 2. Number of Interventions



bilaterally. Ureteral stones were detected in 19 patients (20.9%) (7 right, 10 left, 2 bilateral). A bladder stone was found in one patient (1.1%). Combined localizations occurred in two patients: one with stones in the right kidney and right ureter, and another with stones in the right ureter and bladder (Figure 1).

An analysis of stone characteristics and clinical presentation demonstrated that the mean stone diameter was 8.53 mm (min: 1 mm – max: 35 mm). The mean follow-up duration was 20.31 ± 17.51 months (min: 4 – max: 80 months). Regarding presenting symptoms, flank pain was the most common, reported in 47 patients (51.65%). Other symptoms included fever in 22 patients (24.18%), hematuria in 14 (15.38%), vomiting in 9 (9.89%), and urinary incontinence in 5 patients (5.49%) (Table 1)

Patients were evaluated according to the type of treatment they received. Retrograde intrarenal surgery (RIRS) was performed in 27 patients (29.67%), ureteroscopy (URS) in 14 (15.38%), and extracorporeal shock wave lithotripsy (ESWL) in 20 (21.98%). Percutaneous nephrolithotomy (PNL) was applied in 5 patients (5.49%), laparoscopic excision in 1 (1.10%), and open surgery in 2 patients (2.20%). In addition, spontaneous stone passage was observed in 22 patients (24.18%) who did not require active intervention (Figure 2)

The number of urinary tract infection (UTI) episodes experienced by patients prior to admission was analyzed. Of the total cohort, 39 patients (42.84%) had no prior history of UTI. A single episode was reported in 21 patients (23.08%), two episodes in 20 patients (21.98%), three episodes in 8 patients (8.80%), and four or more episodes in 3 patients (3.30%) (Figure 3).

The most frequently identified stone group comprised calcium oxalate, calcium phosphate, and mixed forms, detected in 62 patients and representing 68 stones (67.32% of all). Metabolic abnormalities were present in 54% of these cases, with hypercalciuria being the most common disorder (37.09%). Uric acid stones were observed in 8 patients (11 stones), all of whom (100%) demonstrated metabolic disturbances, predominantly hypercalciuria (75%). Among the 7 patients with cystine stones, 85.8% showed metabolic abnormalities, most frequently cystinuria (71.4%). Struvite stones (magnesium ammonium phosphate) were found in 11 patients (13 stones), and hypomagnesemia was present in 90.9% of these cases. Rare mixed compositions—such as calcium oxalate + cystine and calcium phosphate + cystine—were found in 2 patients, both of whom exhibited combined cystinuria and hyperoxaluria, indicating a 100% metabolic abnormality rate in this subgroup.

Among the metabolic disorders, hypercalciuria was the most common, identified in 28 patients (30.8%). This was followed by hyperoxaluria (17.6%; n=16), hypomagnesiuria (11.0%; n=10), hyperuricosuria (8.8%; n=8), cystinuria (8.8%; n=8), and hypocitraturia (5.5%; n=5) (Table 2). Urinary metabolic evaluation demonstrated that 61 out of 91 patients (67.8%) exhibited at least one identifiable abnormality, whereas 30 patients (32.2%) had no detectable metabolic disturbance and were classified as metabolically normal.

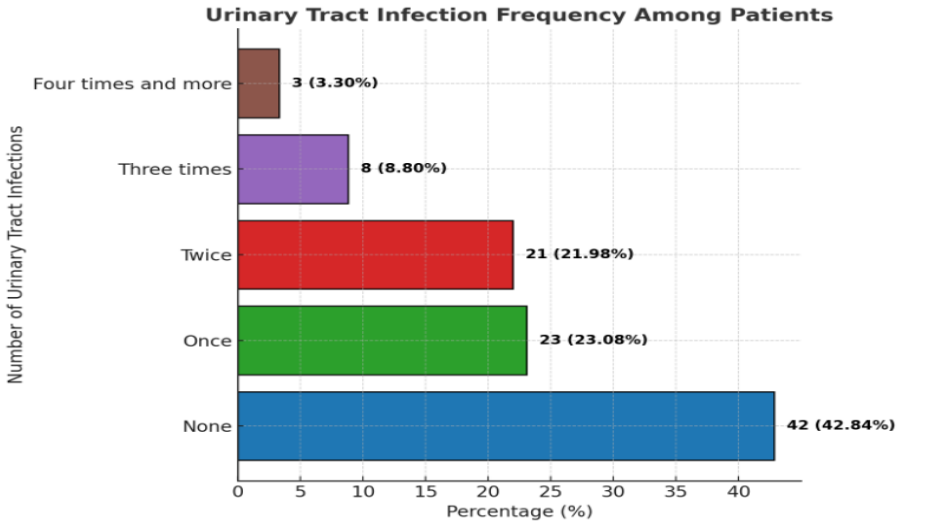
DISCUSSION

Pediatric stone disease has become increasingly prevalent in recent years and has become a significant public health concern. Accordingly, the clinical features, stone localizations, compositions, and metabolic abnormalities of pediatric stone disease have been more extensively evaluated in the literature.

Childhood urolithiasis, in terms of symptoms, varies depending on age and the presence of concomitant urinary tract infections. In preschool children, it typically presents as nonspecific abdominal pain with no clear localization, whereas in adolescents, colicky pain is more prominent (20). Spivacow et al. (2008) reported a mean patient age of 10.7 years in their study and identified flank or abdominal pain as the most common symptom, observed in 76.9% of cases (10). Similarly, Milliner and Murphy (1993) found that more than 50% of patients presented with flank pain (21). Ensari et al. (2024) reported that the most common symptoms were abdominal pain, nausea, vomiting, and macroscopic hematuria (22). Additionally, a review of the literature indicates that gross hematuria, urinary retention, and acute renal failure are rarely observed in pediatric patients with urolithiasis (23). Consistent with previous findings, our study found that flank pain was the most frequently observed symptom (51.65%), followed by fever (24.18%), hematuria (15.38%), vomiting (9.89%), and urinary incontinence (5.49%).

Regarding stone localization, Safaei Asl and Maleknejad (2011) reported that 90.6% of stones were located in the renal pelvis, 3.6% in the ureter, with concurrent kidney and ureter involvement in 3.6%, and isolated bladder stones in 2.4% of cases

Figure 3. Frequency of Urinary Tract Infection



(24). Dönger et al. (2025) similarly reported stones in the renal pelvis in 75.8% of cases, in the ureter in 20%, and in both renal pelvis and ureter in 3% (25). In our study, the most common locations were the renal pelvis (75.8%) and ureter (20%), in line with the literature.

Stone composition has also been widely studied. Lasorsa et al. (2023) reported that calcium oxalate stones were the most common (51.6%), followed by calcium oxalate-phosphate mixed stones (6.5%) and struvite stones (3.2%) (26). Ensari et al. (2024) found calcium oxalate stones in 80% and cystine stones in 20% of their patients (22). Üntan et al. (2021), in a study of 148 patients, reported 88% calcium oxalate, 10% cystine, and 2% uric acid stones (27). Spivacow et al. (2019) reported 50% calcium oxalate, 11% calcium oxalate-phosphate mixed, 22% uric acid, and 5.6% cystine stones (28). There is consensus in the literature that calcium oxalate is the most common stone type. In our study, calcium oxalate stones were observed in 39.6% of cases, calcium oxalate–calcium phosphate mixed stones in 20.79%, uric acid stones in 10.89%, and cystine stones in 6.93%.

Metabolic evaluation plays a critical role in preventing recurrence and planning long-term management. Reported prevalence rates of metabolic abnormalities in pediatric stone disease range from 12.3% to 96% (5,29–30). Ensari et al. (2024) reported that 72% of children with urolithiasis had at least one metabolic abnormality—most commonly hypercalciuria (53%), followed by hypocitraturia (22%) and cystinuria (2%) (22). Elmacı et al. (2014) reported an overall metabolic abnormality rate of 83.2%, with hyperuricosuria (24.5%) and hypocitraturia (23.8%) being most frequent, followed by hyperoxaluria (21.7%) and hypercalciuria (21%), while cystinuria was the least common (7.4%). Safaei Asl and Maleknejad reported 52.5% metabolic abnormalities, with hypercalciuria (21.7%) as the most common, followed by hyperuricosuria (11.5%) and hypocitraturia (10.2%) (24). In a study of 325 pediatric patients, Dönger et al. (2025) found hypocitraturia (26.2%) to be the most common, followed by hypercalciuria (17%) and hyperoxaluria (16.3%) (25). They attributed high rates of hypercalciuria and hyperoxaluria (~43%) to hot climates and insufficient hydration. Spivacow et al. (2020) reported 89.3% metabolic abnormalities, with hypercalciuria being the most frequent (47%) (28). Other studies have reported hypercalciuria rates as high as 54–79% (30,32–33).

In our cohort, metabolic abnormalities were present in 67.8% of patients. Hypercalciuria was most common (30.8%), followed by hyperoxaluria (17.6%) and hypomagnesuria (11%). Hyperuricosuria and cystinuria were each found in 8.8%. Although hypercalciuria was consistent with prior studies, hypocitraturia

Table 2. Type of Metabolic Disorders

Metabolic Disorder	Total Count	Percentage (%)	Patients Affected (%)
Hypercalciuria	28	30.8	30.8
Hyperoxaluria	16	17.6	17.6
Hypomagnesiuria	10	11.0	11.0
Hyperuricosuria	8	8.8	8.8
Cystinuria	8	8.8	8.8
Hypocitraturia	5	5.5	5.5

** A single patient may exhibit more than one metabolic abnormality.*

was relatively rare (5.5%). This may be due to dietary patterns, such as lower animal protein consumption, which may reduce renal citrate reabsorption and result in higher urinary citrate levels.

CONCLUSION

In pediatric urinary stone disease, in addition to environmental influences, metabolic factors are considered to play a significant role. Metabolic evaluation not only contributes to the identification of potential underlying genetic disorders but also plays a crucial role in minimizing recurrences. Consistent with our findings, we recommend routine metabolic assessment in pediatric patients with urinary stone disease. The retrospective design and the limited sample size of our study represent its main limitations. Further investigations with larger patient cohorts will be valuable in contributing to the existing literature.

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Authorship Contributions: Concept: EY, DG; Design: EY, DY; Supervision: EY; AID; Materials: EY, CAA; Data Collection or Processing: HEA; Analysis or Interpretation: DG; Literature Review: EY; Writing: EY; Critical Review: CAA.

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