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Clinical and Metabolic Characteristics in Children with Nephrolithiasis and the Role of These Factors in Stone Resolution: A Retrospective Cohort Study

Nefrolitiazisli Çocuklarda Klinik ve Metabolik Özellikler ve Bu Faktörlerin Taş Çözülmesindeki Rolü: Retrospektif Kohort Çalışması

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ABSTRACT Objective: Nephrolithiasis is a health problem that leads to frequent hospital admission in children. There are risk factors such as anatomical problems leading to urinary stasis, infections, and some metabolic abnormalities. This study involved the assessment of clinical and laboratory information from pediatric patients, with an analysis of factors that could impact treatment outcomes. **Material and Methods:** In this study, the clinical and laboratory records of children aged 0-18 years diagnosed with nephrolithiasis were retrospectively analyzed. The assessments of patients' information with resolved or persistent kidney stones were compared, identifying risk factors for persistence. **Results:** This study included 278 patients, with a slight female predominance (male/female: 1/1.17) and a mean age of 4.9 years (0.1-17.5 years). Most patients (29.5%) were diagnosed incidentally. Approximately half of the patients (45.3%) had at least 1 metabolic risk factor, hyperoxaluria is the most common one (18.7%). More than half of the patients (57.9%) have microlithiasis. The frequency of microlithiasis increases in males, younger age, hypercalciuria, hyperuricosuria and hypocitraturia. Overall treatment success rate is 60.8%, and it is higher in males, microlithiasis, left nephrolithiasis, and in the absence of hyperoxaluria or hypocitraturia. **Conclusion:** Metabolic examinations should be performed in every patient regardless of stone size. Treatment success can be predicted according to the underlying metabolic risk factor and individualized treatment becomes important. Since microlithiasis may improve spontaneously, the need for medical treatment should be evaluated individually for each patient.

Keywords: Metabolic diseases; nephrolithiasis; urolithiasis; pediatrics

ÖZET Amaç: Nefrolitiyazis çocuklarda sık hastaneye başvuruya neden olan bir sağlık sorunudur. Üriner staza yol açan anatomik sorunlar, enfeksiyonlar ve bazı metabolik anormallikler taş oluşumu için risk faktörleridir. Bu çalışma, böbrek taşı olan çocuklarda tedavi sonuçlarını etkileyebilecek faktörlerin analizi ile klinik ve laboratuvar bulguların değerlendirilmesini içermektedir. **Gereç ve Yöntemler:** Bu çalışmada nefrolitiyazis tanısı konulan 0-18 yaş arası çocukların klinik ve laboratuvar kayıtları retrospektif olarak analiz edilmiştir. Takip süresi sonunda, böbrek taşları çözülmüş veya devam eden hastaların klinik ve laboratuvar bilgileri karşılaştırılarak taşların kalıcılığını etkileyen risk faktörleri belirlenmiştir. **Bulgular:** Bu çalışmaya böbrek taşı olan 278 pediatrik hasta dâhil edilmiş olup, kız cinsiyeti daha baskın saptanmıştır (erkek/kız: 1/1,17) ve ortalama yaş 4,9 yıldır (0,1-17,5 yıl). En sık tanı (%29,5) insidental olarak konulmuştur. Hastaların yaklaşık yarısında (%45,3) en az 1 metabolik risk faktörü vardır, hiperoksalüri en yaygın olanıdır (%18,7). Hastaların yarısından fazlasında (%57,9) mikrolitiazis mevcuttur. Mikrolitiazis sıklığı erkeklerde, genç yaşta, hiperkalsiüri, hiperürikozüri ve hipositratüride artmaktadır. Genel tedavi başarısı %60,8'dir ve erkeklerde, mikrolitiaziste, sol nefrolitiyaziste ve hiperoksalüri veya hipositratüri yokluğunda daha yüksektir. **Sonuç:** Taş boyutuna bakılmaksızın her hastada metabolik incelemeler yapılmalıdır. Altta yatan metabolik risk faktörüne göre tedavi başarısı öngörülebilir ve bireyselleştirilmiş tedavi önem kazanır. Mikrolitiazis spontan olarak iyileşebileceğinden, medikal tedavi ihtiyacı her hasta için ayrı ayrı değerlendirilmelidir.

Anahtar Kelimeler: Metabolik hastalıklar; nefrolitiyazis; ürolitiyazis; pediatri

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Nephrolithiasis is a health problem that leads to frequent hospital admission in children and may cause important complications such as chronic kidney disease and kidney failure in advanced cases.[1] The prevalence in adults is reported as 14.8% and is similar in children in our country.[2,3] It is more common in boys.[4] There are risk factors such as anatomical problems leading to urinary tract stenosis and urinary stasis, infections, endocrine and some metabolic risk factors that facilitate the development of urinary calculi. Metabolic risk factors can be categorized as an increase in factors that cause stone formation and a decrease in factors that inhibit it. Hypercalciuria, hyperuricosuria, cystinuria and hyperoxaluria are among the lithogenic factors, while hypercitraturia inhibits stone formation.[5] The prevalence of any metabolic risk factor in nephrolithiasis has a wide range and has been reported as 30-90% in children in various studies.[6-9] Treatment of nephrolithiasis in children with metabolic risk factors may require a more comprehensive approach, including management of the underlying metabolic abnormalities. Therefore, these patients may often have lower success rates compared to patients without metabolic risk factors.[10]

Calyceal microlithiasis is characterized by small, bright spots measuring less than 3 mm in diameter within the kidney calyces. This finding marks the initial stage of stone development.[8] It is commonly observed in infants, and metabolic irregularities can predispose to future stone formation, potentially resulting in larger stones over time. Therefore, intervention to address metabolic risk factors may in microlithiasis prevent the development of these clinical outcomes.[11] However, some studies have also shown spontaneous regression of calyceal microlithiasis.[6]

This study reviewed clinical and laboratory records of pediatric patients undergoing follow-up for kidney stones and analyzed factors that could influence treatment outcomes.

MATERIAL AND METHODS

STUDY POPULATION AND DEFINITIONS

This study involved a retrospective review of medical records from children aged 0-18 years diagnosed with kidney stones and treated at our hospital's pediatric nephrology outpatient clinic between January 2019 and April 2024. Patients with endocrine or metabolic disorders were excluded. Kidney stone diagnoses were confirmed based on findings from ultrasonography or tomography. Microlithiasis was identified if renal ultrasound scans showed stone dimensions <3 mm.[8] All patients underwent regular reassessment at our facility through sequential ultrasound examinations conducted every 1-3 months. The objective was to validate the diagnosis, eliminate any artifacts, and monitor the status of kidney stones over time.

Age, sex, presenting symptoms and family history of kidney stones were documented in patient records. Family history was considered positive if at least one family member had a history of kidney stones. Laboratory investigations included blood and urine tests (Blood tests: blood urea nitrogen, creatinine, sodium, potassium, chloride, calcium, phosphorus, magnesium, venous blood gas. Urine tests: spot urine levels of calcium, uric acid, oxalate, cystine, citrate, and creatinine). In addition, serum alkaline phosphatase, vitamin D and parathormone levels, which are related to calcium metabolism, were examined in patients with hypercalciuria. Metabolites in spot urine samples were standardized by dividing by urinary creatinine levels. Laboratory limits for hypercalciuria, hyperuricosuria, hyperoxaluria, cystinuria, and hypocitraturia were defined in Table 1.

The follow-up periods of patients in our department were documented. Patients identified with metabolic risk factors received tailored treatment based on their specific metabolic abnormalities. Management strategies for patients with kidney stones involved increasing fluid intake, adhering to a low-sodium diet, using pyridoxine, hydrochlorothiazide, potassium citrate, or a combination of potassium citrate and sodium citrate. Surgical treatment was advised for children with obstructive or infected urolithiasis. The analysis of urinary stone composition was conducted using X-ray diffraction, either on stones that were passed naturally or those that were surgically removed. Recent ultrasound assessments documented the presence, location, and size of the kidney stones. The resolution of stone disease was

TABLE 1: Laboratory limits of metabolic risk factors (expressed as metabolite/creatinine ratio in urine)

Metabolic risk factors	Limits of metabolite/creatinine ratio in urine
Hypercalciuria (mg/mg)[5]	
0-12 months	0.8
1-3 years	0.053
3-5 years	0.4
3-7 years	0.3
7-18 years	0.2
Hyperuricosuria (mg/mg)[5]	
0-12 months	2.2
1-3 years	1.9
3-5 years	1.5
5-10 years	0.9
10-18 years	0.6
Hyperoxaluria (mg/g)[5]	
0-6 months	288
7-24 months	139
2-5 years	80
5-14 years	65
14-18 years	32
Hypocitraturia (g/g)[12]	
0-5 years	0.2
5-18 years	0.14
Cystinuria (µmol/g)[5]	
0-2 months	573
3-8 months	461
9-24 months	186
2-12 years	98
13-18 years	81

The values given for hypercalciuria, hyperuricosuria, hyperuricosuria, hyperoxaluria and cystinuria indicate the upper limits, while the values given for hypocitraturia indicate the lower limits.

defined as the complete and permanent elimination of stones, as confirmed by follow-up ultrasound scans. At the end of the following period, the clinical and laboratory features of patients with resolved versus persistent kidney stones were compared to identify risk factors associated with stone persistence.Formun Üstü

The research was granted ethical approval by the Ethics Committee of KTO Karatay University Faculty of Medicine (Date: June 7, 2024, No: 86400), and all procedures followed the guidelines outlined in the Helsinki Declaration. Informed consent was secured from all participants or their legal representatives before they took part in the study.

STATISTICAL ANALYSIS

In the presentation of descriptive statistics; measured data will be expressed as mean±standard deviation and (minimum-maximum) and categorical data will be expressed as number (percentage). Cross-table analyses and Fisher's exact chi-square tests will be used to compare the qualitative characteristics of the groups. The conformity of the numerical measurements in the groups to the normal distribution will be examined with the Shapiro Wilks test. Two-group comparisons will be made by independent samples t-test for those with normal distribution in numerical measurements and Mann-Whitney U test for those without normal distribution.

RESULTS

CLINICAL CHARACTERISTICS AND LABORATORY EVALUATIONS OF THE PATIENTS

The study involved 278 patients. There was a higher prevalence of females compared to males, with a ratio of 1.17:1. The average age of the participants was 4.90 years (0.1-17.5 years). The age group with the highest patient population was 0-1 years (n=87, 31.3%). This was followed by 3-8 years (n=62, 22.3%), 1-3 years (n=54, 19.4%), 8-14 years (n=48, 17.3%) and 14-18 years (n=27, 9.7%). Fifty-three patients (19.1%) had a family history of nephrolithiasis. Flank pain or restlessness were among the presenting symptoms, accounting for 25.2% (n=70), and urinary tract infection (15.1%; n=42), and hematuria (15.1%; n=42) were commonly observed. A total of 82 patients (29.5%) were incidentally diagnosed. The majority of patients who were diagnosed with kidney stones during urinary tract infection and those who were diagnosed incidentally were female (69% and 62.2%, respectively) (p=0.000).

Among laboratory findings, serum creatinine was within normal range in all patients. Hyperuricemia was present in a total of 6 patients (2.2%). Serum electrolytes were also normal in all patients. Three (1.1%) patients had mild metabolic acidosis, however no metabolic alkalosis. Vitamin D levels were checked in 56 patients and found to be low in 37 (66.1%). There was no parathyroid disease in etiologic evaluation. The mean urine pH was 6.23±0.86.

The average calcium/creatinine ratio in spot urine was 1.40±2.74 mg/mg, uric acid/creatinine 0.30±0.41 mg/mg, oxalate/creatinine 95.9±88.2 mg/g, citrate/creatinine 883.6±837.1 mg/g, cystine/creatinine 148.1±396.6 µmol/g. At least one metabolic disorder was found in 126 (45.3%) patients. Hypercalciuria was present in 31 (11.2%), hyperuricosuria in 19 (6.8%), hyperoxaluria in 52 (18.7%), cystinuria in 32 (11.5%) and hypocitraturia in 20 (7.2%) patients. When analyzed according to age groups, hypercalciuria was most common in the 0-1 age group (21.8%) and the frequency decreased with increasing age (p=0.001). Hyperoxaluria was most common in the 3-8 age group (27.4%), 23.1% in the 14-18 age group and 18.8% in the 8-14 age group. The lowest frequency was 5.7% in the 0-1 age group (p=0.000). Only 13 (4.6%) patients underwent stone analysis, calcium oxalate stones were found in 9 (69.2%) patients, and uric acid and struvite stones were found in 2 (15.3%) patients each (Table 2).

At the time of diagnosis, more than half of the patients (n=146, 52.5%) had stones in the left kidney, while 51 (18.3%) had stones in the right kidney. Eighty-one (29.1%) patients had bilateral nephrolithiasis. A total of 19 (6.8%) patients had ureteral stone (Table 3). Right nephrolithiasis was more frequently observed in females (22% vs. 14.1%), whereas bilateral nephrolithiasis was more prevalent in males (31.3% vs. 27.3%) (p=0.224). Ureteral stones were also more common in males (9.4% vs. 4.7%, p=0.095). Patients with right nephrolithiasis were older on average compared to those with left nephrolithiasis (6.78±5.40 vs. 4.95±5.10), while those with bilateral nephrolithiasis had the lowest average age (3.63±4.51) (p=0.007). The mean age of patients with ureteral stones was significantly higher than that of those without ureteral stones (10.55±7.28 vs. 4.49±4.64, p=0.000). Analyses did not reveal significant differences in metabolic risk factors related to kidney stone location, nor was there a notable correlation between stone composition and its location. However, patients with ureteral stones had higher prevalences of hyperoxaluria and cystinuria compared to those without ureteral stones (42.1% vs. 17%, p=0.025 and 36.8% vs. 9.7%, p=0.009, respectively) (Table 3).

TABLE 2: The clinical features and laboratory results of the patients

	n (%)	X̄±SD	Median	Minimum-maximum
Age (years)		4.90±5.09	2.80	0.1-17.5
Sex				
Male	128 (46)			
Family history	53 (19.1)			
Presenting symptoms				
Incidentally diagnosed	82 (29.5)			
Flank pain or restlessness	70 (25.2)			
UTI	42 (15.1)			
Hematuria	42 (15.1)			
Spontaneous stone passage	8 (2.9)			
Localizations of stone				
Left kidney	146 (52.5)			
Right kidney	51 (18.3)			
Bilateral kidneys	81 (29.1)			
Ureter	19 (6.8)			
Size of the stones		3.56±3.03	3	1-25
Microlithiasis	161 (57.9)			
>3 mm	117 (42.1)			
Number of the stones in a patient		2.17±1.47	1	1-6
Stone analysis (n=19)				
Ca oxalate	9 (47.3)			
Uric acid	2 (10.5)			
Sitruvite	2 (10.5)			
Laboratory evaluations				
Blood				
Creatinine (mg/dL)		0.38±0.17	0.35	0.17-0.94
BUN (mg/dL)		9.08±3.94	9	2-27
Uric acid (mg/dL)		3.89±1.17	3.8	0.9-7.1
Ca (mg/dL)		9.98±0.47	10	8.8-11.2
P (g/dL)		4.92±0.86	4.8	3-6.6
Mg (mg/dL)		2.09±0.18	2.1	1.78-2.56
Na (mEq/L)		138.6±2.1	138	132-145
K (mEq/L)		4.57±0.49	4.5	3.4-5.9
25-OH Vitamin D (ng/mL) (n=56)		25.9±15.9	22.4	5.3-83.6
pH		7.38±0.04	7.39	7.23-7.46
HCO3 (mEq/L)		22.5±1.7	22.9	17.2-25.7
Urine				
pH		6.23±0.86	6	5-8.5
Density		1014.3±9.2	1014	1001-1038
Eryhtrocyte (/HPF)		14.5±60.6	1	0-600
Metabolic evaluations				
Ca/creatinine (mg/mg)		1.40±2.74	1.03	0.22-27.6
Hypercalciuria	31 (11.2)			
Uric acid/creatinine (mg/mg)		0.30±0.41	0.13	0-3.39
Hyperuricosuria	19 (6.8)			
Oxalate/creatinine (mg/g)		95.9±88.2	75.2	0.63-612
Hyperoxaluria	52 (18.7)			
Citrate/creatinine (mg/g)		883.6±837.1	675	6.95- 6963
Hypocitraturia	20 (7.2)			
Cystine/creatinine (µmol/g)		148.1±396.6	72.9	2.01-3900
Cystinuria	32 (11.5)			

UTI: Urinary tract infection; BUN: Blood urea nitrogen; Ca: Calcium; P: Phosphorus; Mg: Magnesium; Na: Sodium; K: Potassium; HCO3: Bicarbonate; HPF: High power field

TABLE 3: The comparison of stone location and other characteristics of the patients

	Nephrolithiasis						Ureteral stone				
	Left kidney (n=146)		Right kidney (n=51)		Bilateral kidneys (n=81)			Present (n=19)		Absent (n=259)	
	n (%)	X̄±SD	n (%)	X̄±SD	n (%)	X̄±SD	p value	n (%)	X̄±SD	n (%)	X̄±SD	p value
Age (years)		4.95±5.1		6.78±5.4		3.63±4.51	0.002		10.55±7.28		4.49±4.64	0.000
Sex												
Male	70 (47.9)		18 (35.3)		40 (49.4)		0.224	12 (63.2)		116 (44.8)		0.095
Female	76 (52.1)		33 (64.7)		41 (50.6)			7 (36.8)		143 (55.2)		
Size of the stones		3.70±3.38		3.80±2.18		3.15±2.80	0.346		6.06±2.46		2.20±1.49	0.000
Microlithiasis	85 (58.2)		25 (49)		51 (63)		0.287	3 (15.8)		158 (61)		0.000
>3 mm	61 (41.8)		26 (51)		30 (37)			16 (84.2)		101 (39)		
Number of the stones in a patient		1.58±1.07		1.51±0.92		3.67±1.31	0.000		1.84±1.21		2.20±1.49	0.313
Metabolic evaluations												
Hypercalciuria	14 (9.6)		9 (17.6)		8 (9.8)		0.113	3 (15.7)		28 (10.8)		0.624
Hyperuricosuria	7 (4.8)		3 (5.8)		9 (11.1)		0.064	0 (0)		19 (7.3)		0.011
Hyperoxaluria	22 (15.1)		9 (17.6)		21 (25.9)		0.365	8 (42.1)		44 (17)		0.025
Hypocitraturia	15 (10.3)		3 (5.9)		2 (2.5)		0.066	1 (5.3)		19 (7.3)		0.298
Cystinuria	15 (10.3)		9 (17.6)		8 (9.9)		0.368	7 (36.8)		25 (9.7)		0.009

The mean number of stones in a patient was 2.17±147 and the mean maximum stone diameter was 3.56±3.03 mm. The number of patients with microlithiasis was 161 (57.9%) and the number of patients with a maximum stone diameter of more than 3 mm was 117 (42.1%) (Table 2). The frequency of microlithiasis was higher in males (64.1% vs 52.7%, p=0.036). The mean age of patients with microlithiasis was significantly lower than that of patients with larger stones (3.73±4.57 vs 6.51±5.33, p=0.000). The prevalence of hyperoxaluria and cystinuria was higher in patients with stones larger than 3 mm compared to patients with microlithiasis (25.6% vs. 13.7%, p=0.000 and 17.1% vs. 7.5%, p=0.001, respectively). Patients with microlithiasis had a higher frequency of hyperuricosuria, hypercalciuria and hypocitraturia than patients with larger stones (8.7% vs. 4.3%, p=0.000, 13% vs. 8.5%, p=0.034 and 9.3% vs. 4.3%, p=0.027, respectively). The comparison of stone size and other characteristics is presented in Table 4.

OUTCOMES AT THE END OF THE FOLLOW-UP AND PARAMETERS AFFECTING TREATMENT SUCCESS

The average follow-up duration was 7.6±12.5 months. In 121 (43.5%) patients, recommendations such as increasing fluid consumption and salt-free diet were made, while a total of 157 (56.5%) patients received medical and/or surgical treatment in addition to these general recommendations. The most common medical treatment was potassium citrate solution (n=111, 39.9%) and the most common surgical procedure was retrograde intrarenal surgery (RIRS) (n=10, 3.6%) (Table 5).

At the last urinary ultrasound, 109 (39.2%) patients still had nephrolithiasis. The frequency was lower in males (31.3% vs 44.7%, p=0.015). Patients with stones in their right kidneys were stone-free in 52.9% of cases, while in patients with stones in their left kidneys, stones were not detected in 61.6% of cases (p=0.415). Compared to the time of diagnosis, the frequency of

TABLE 4: The comparison of stone size and other characteristics of the patients

	Microlithiasis (<3 mm) (n=161)		Nephrolithiasis (>3 mm) (n=117)		
	n (%)	X̄±SD	n (%)	X̄±SD	p value
Age (years)		3.73±4.57		6.51±5.09	0.000
Sex					
Male	82 (50.9)		46 (39.3)		0.036
Female	79 (49.1)		71 (60.7)		
Location of the stones					
Left kidney	85 (52.8)		61 (52.1)		0.287
Right kidney	25 (15.5)		26 (22.2)		
Bilateral kidneys	51 (31.7)		30 (25.6)		
Ureters	3 (1.9)		16 (13.7)		0.000
Number of the stones in a patient		2.35±1.56		1.92±1.30	0.016
Metabolic evaluations					
Hypercalciuria	21 (13)		10 (8.5)		0.017
Hyperuricosuria	14 (8.7)		5 (4.3)		0.000
Hyperoxaluria	22 (13.7)		30 (25.6)		0.000
Hypocitraturia	15 (9.3)		5 (4.3)		0.025
Cystinuria	12 (7.5)		20 (17.1)		0.001

TABLE 5: The treatment modalities applied in the patients

	n (%)	X̄±SD	Median	Minimum-maximum
Follow-up time (months)		7.60±12.5	5.5	2.5-127
Treatments				
General recommendations	121 (43.5)			
Drugs				
Potassium citrate (liquid)	111 (39.9)			
Potassium citrate (tablet)	9 (3.2)			
Allopurinol	12 (4.3)			
Pyridoxine	8 (2.9)			
Captopril	6 (2.2)			
Surgery				
RIRS	10 (3.6)			
ESWL	8 (2.8)			
PNL	3 (1.1)			
URS	2 (0.7)			
ECIRS	2 (0.7)			
Treatment success				
Stone-free patients	169 (60.8)			

RIRS: Retrograde intrarenal surgery; ESWL: Extracorporeal shockwave lithotripsy; PNL: Percutaneous nephrolithotomy; URS: Ureteroscopy; ECIRS: Endoscopic combined intrarenal surgery

stones in the right kidney increased at the end of follow-up (18.3% vs. 22%, p=0.041). The mean number of stones in a patient at the last ultrasound was significantly lower than before treatment (1.90±1.38 vs. 2.30±1.64 stones, p=0.001). Similarly, the mean maximum stone size at the last ultrasound was less than before treatment (3.50±2.72 mm vs. 3.93±2.45, p=0.035).

When evaluated according to metabolic risk factors, 55.8% of patients with hyperoxaluria had no stones at the end of the follow-up, while 62.9% of children without hyperoxaluria had no stones (p=0.027). At the end of the follow-up, only 30% of patients with hypocitraturia showed improvement regarding their stones, while 65.4% of patients with elevated urinary citrate/creatinine ratios had no stones at the final follow-up (p=0.007). No significant correlation was found between other metabolic risk factors and the presence of stones at the last visit.

While 68% of patients with microlithiasis were stone-free, 32% of patients with stone size larger than 3 mm were stone-free at the last visit (p=0.000). In patients with microlithiasis, the rate of renal stone disappearance at the last ultrasound was 61.1% in those receiving medical treatment and 76.6% in those not receiving medical treatment (p=0.032). In patients with stone size larger than 3 mm, the rate of stone detection at the last ultrasound was lower in the group receiving medical treatment compared to the group not receiving medical treatment (52.4% vs. 64.3%, p=0.293).

DISCUSSION

In this study, the frequency of kidney stones was found to be higher in girls. Family history was positive in almost 1 in 5 patients. Kidney stones were most diagnosed as incidentally. Approximately half of the patients had at least 1 metabolic risk factor, hyperoxaluria is the most common one. Left nephrolithiasis was found in more than half of the patients. However, right nephrolithiasis is more common in girls and bilateral nephrolithiasis is more common in boys. More than half of the patients have microlithiasis. The frequency of microlithiasis increases in males, younger age, hypercalciuria, hyperuricosuria and hypocitraturia. In hyperoxaluria and cystinuria, there is a risk of larger stones. More than half of the patients underwent medical and/or surgical intervention. Overall treatment success rate is 60.8%, and it is higher in males, microlithiasis, left nephrolithiasis, and in the absence of hyperoxaluria or hypocitraturia.

In many studies, a male predominance is typically observed among children with kidney stones.[13] However, our study found a higher number of females affected by kidney stones. This may be because the majority of patients with incidental kidney stones were female. If abdominal imaging had been performed in asymptomatic males for other reasons, perhaps the frequency of males with stones would have been higher in our study. In addition, it is known that urinary tract infection is more common in girls than in boys.[14] In our study, the majority of patients evaluated for urinary tract infection were girls. Therefore, this may be the reason for the higher incidence of stones in girls. Kidney stones commonly occur in the upper urinary tract.[4,15] In our study, renal calculi were predominantly located in the pelvicalyceal system. Stones in the ureter were present in only 6.8% of patients, and none of the patients had bladder stones. Previous research has indicated that patients with stones in the upper urinary system tend to be older compared to those with lower urinary system stones.[16] Unexpectedly, in our study, the average age of patients with ureteral stones was significantly greater than that of patients with stones in the upper urinary tract.

In Türkiye, the incidence of chronic kidney disease secondary to kidney stones ranges from 4% to 8%.[6,17] Fortunately, all our patients had kidney function test results within the normal range. This could be attributed to the relatively young average age of our patients, the relatively short follow-up period of just 10 months, and the fact that they were diagnosed before significant obstruction and renal parenchymal damage occurred.

Metabolic risk factors causing the formation of kidney stones are present in 10-95% of patients with kidney stones in various studies.[6,18,19] Therefore, metabolic risk factors should be investigated in every patient evaluated for kidney stones. In Türkiye, hypercalciuria and hypocitraturia are important risk factors.[20-22] In our study, at least one metabolic risk factor was found in approximately half of the patients. Hyperoxaluria was the most common risk factor, followed by hypercalciuria and cystinuria. The reason for these different risk factors compared to other studies in our country may be related to the dietary habits in Konya province. Various studies are needed to determine whether people living in Konya have a diet rich in oxalate by evaluating the foods commonly consumed. In addition, age groups were not equally distributed in this retrospective study. The frequency of oxaluria was found to be higher in the age range of 3-18 years. A difference in the frequency of hyperoxaluria may be observed if a similar number of patients are examined at each age.

The common symptoms and signs of kidney stones include urinary tract infection in young infants, hematuria between the ages of 1-5 years and abdominal pain above the age of 5 years.[6] In our study, kidney stones were most commonly recognized during urinary system ultrasound performed for another reason. Flank pain, bloody urine and urinary tract infection are other common symptoms and findings. Therefore, patients with recurrent urinary tract infection, abdominal pain and hematuria should be evaluated in terms of kidney stones.[23]

Microlithiasis is usually observed in young infants.[6] Although some studies have reported that microlithiasis transforms into larger kidney stones over time, there are also studies showing that it does not

increase stone formation.[24,25] In our study, the lower rate of stone detection in patients with microlithiasis at the end of the follow-up period suggests that microlithiasis is less likely to became larger over time. When metabolic risk factors in patients with microlithiasis were analyzed, only hypercalciuria was found to be significantly associated with microlithiasis.[6] In our study, in addition to hypercalciuria, the frequency of microlithiasis increased in hyperuricosuria and hypocitraturia.

In this study, several clinical and metabolic parameters were found to be associated with the success of kidney stone treatment in pediatric patients. The overall stone resolution rate of approximately 60% aligns with previous literature reporting spontaneous or treatment-related stone clearance rates ranging from 50% to 70% in children.[6,13,24,25] Notably, the presence of microlithiasis was significantly associated with better outcomes, with higher rates of stone clearance observed even in the absence of medical therapy.[6,24] This finding supports earlier observations suggesting that small, non-obstructive calculi may resolve spontaneously, particularly in younger children and in the absence of significant metabolic abnormalities. In addition, in patients with stone size larger than 3 mm, the rate of stone disappearance is higher in the group receiving medical treatment compared to the group not receiving medical treatment. This suggests that drug treatment is much more necessary in patients with nephrolithiasis. The data also indicate a negative prognostic impact of hypocitraturia, consistent with the known inhibitory role of citrate in urinary crystallization. Previous studies have demonstrated that low urinary citrate is a major risk factor for recurrent stone formation and treatment failure.[5,9,23] In contrast, hyperoxaluria showed a modest but statistically significant association with lower treatment success, underscoring the importance of metabolic evaluation in all pediatric stone patients, regardless of stone size or clinical presentation. Interestingly, the resolution rate was higher in patients with left-sided nephrolithiasis, although the difference did not reach statistical significance. The observed increase in right-sided stones during follow-up raises questions regarding potential anatomical or functional predispositions, which warrant further investigation with imaging modalities such as scintigraphy or magnetic resonance imaging urography.[26,27] Taken together, the findings highlight the need for individualized management strategies in pediatric nephrolithiasis. In cases of microlithiasis and absence of high-risk metabolic abnormalities, a conservative approach with close monitoring may be appropriate, whereas patients with metabolic derangements such as hypocitraturia may benefit from early and targeted pharmacologic intervention.

This study has several limitations that should be acknowledged. First, its retrospective design inherently carries risks of information bias, and the variability in follow-up duration among patients may have influenced the assessment of treatment outcomes. Second, adherence to dietary and medical recommendations was not objectively verified, which could have affected the stone resolution rates. Third, stone evaluation was performed exclusively using ultrasonography, which, while practical and radiation-free, may have limitations in detecting small or radiolucent stones. Importantly, genetic analysis was not performed as part of this study. Given the increasing recognition of monogenic causes in early-onset or recurrent nephrolithiasis-particularly in cases with consanguinity, positive family history, or nephrocalcinosis-the absence of molecular testing represents a significant limitation. Genetic evaluation in selected high-risk patients could have identified specific etiologies such as primary hyperoxaluria, Dent disease, or cystinuria, which may alter therapeutic approaches and prognosis.[28] Future prospective studies incorporating genetic testing would allow for better characterization of underlying etiologies and promote more individualized treatment strategies in pediatric nephrolithiasis.

CONCLUSION

The kidney stones are a fairly common disease in children. Although the diagnosis is usually made incidental, children with flank pain, bloody urine and urinary tract infection should be examined for kidney stones. Although microlithiasis is more common in young children, these patients should be followed up for the development of larger stones in the future.

Since metabolic risk factors that increase the risk of kidney stones are frequently detected, metabolic examination should be performed in every stone patient regardless of the size. Especially in microlithiasis, where the stone size is smaller, the need for medical treatment should be evaluated individually for each patient.

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Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Emre Leventoğlu, İlhan Boğaz;* ***Design:*** *Emre Leventoğlu, İlhan Boğaz;* ***Control/Supervision:*** *Emre Leventoğlu, Mustafa Soran;* ***Data Collection and/or Processing:*** *Emre Leventoğlu, İlhan Boğaz, Derya Cevizli, Mustafa Soran;* ***Analysis and/or Interpretation:*** *Emre Leventoğlu, Derya Cevizli;* ***Literature Review:*** *Emre Leventoğlu, İlhan Boğaz, Derya Cevizli, Mustafa Soran;* ***Writing the Article:*** *Emre Leventoğlu, İlhan Boğaz;* ***Critical Review:*** *Derya Cevizli, Mustafa Soran.*

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