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# Evaluation of ureteral jet dynamics in pediatric kidney stone formers: A cross-sectional study

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## Summary

### Introduction
The risk of kidney stone formation increases with urinary stasis, which is associated with decreased peristaltism. The relationship between non-obstructive kidney stone formation and ureteral jet dynamics, which can be measured with Doppler ultrasonography (US) and provide information about ureteral peristaltism, has been demonstrated in adults.

### Objective
To investigate the relationship between ureteral jet dynamics, which provide information about ureteral peristaltism, and stone formation in children.

### Study design
Children admitted to Dokuz Eylul University Hospital with flank pain, and asymptomatic age-matched children for the control group, were prospectively enrolled and underwent Doppler US for diagnostic reasons and bilateral ureteral jet flow measurements. Children diagnosed with unilateral non-obstructive lower pole kidney stones formed Group 1, and the control group, without any evidence of stone disease, formed Group 2. Ureteral jet dynamics were compared between the affected renal units in Group 1, and healthy renal units in Group 1 and Group 2.

### Results
A total of 32 children were included for each group. The mean average jet flow-rate (JETave (cm/second)) in affected renal units in Group 1 was found to be significantly lower than in the healthy renal units in Group 1 and left and right healthy renal units in Group 2 ($P < 0.05$). The continuous JETpattern rate in affected renal units in Group 1 was found to be significantly higher compared with healthy renal units in Groups 1 and 2 ($P = 0.012$) (Table). The odds ratio for kidney stone formation was 5.6 for renal units with JETave <9.5 cm/s when compared with renal units with JETave ≥9.5 cm/s.

### Discussion
In a recent study, it was demonstrated in adults that low ureteral jet flow-rate and continuous JETpattern were significantly higher in affected renal units. The findings in children were also similar to adults: the mean JETave was significantly lower and determination rate of continuous flow pattern was significantly higher in affected renal units.

### Conclusions
Children with low JETave and continuous JETpattern as a sign of decreased ureteral peristaltism are at an increased risk of kidney stone formation. However, it is vital that further studies are conducted to elaborate on this topic.

**Summary Table** Comparison of JETave and continuous jet flow pattern between affected renal units in Group 1, and healthy renal units in Group 1, healthy left renal units in Group 2 and healthy right renal units in Group 2.

| | Group 1 affected renal units (n = 32) | Group 1 healthy renal units (n = 32) | P* | Group 2 left healthy renal units (n = 32) | P† | Group 2 right healthy renal units (n = 32) | P° |
|---|---|---|---|---|---|---|---|
| JETave (cm/second) (min–max) | 8.6 ± 5.7 (1.5–22.6) | 11.6 ± 5.5 (3.0–25.3) | 0.038 | 12.8 ± 6.5 (3.6–28.6) | 0.008 | 13.4 ± 10.2 (3.0–49.3) | 0.023 |
| Continuous JETpattern (%) | 6 (18.7) | 0 (0) | 0.012 | 0 (0) | 0.012 | 0 (0) | 0.012 |

*P-value between affected and healthy renal units in Group 1.
†P-value between affected renal units in Group 1 and left healthy renal units in Group 2.
°P-value between affected renal units in Group 1 and right healthy renal units in Group 2.

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## Introduction

Ureteral jets are defined as urine flow from the ureters through the ureterovesical junction into the bladder. Doppler ultrasonography (US) is the main method of evaluation [1,2]. Ureteral jet dynamics provide significant information about ureteral physiology and peristaltism, and have been used for the evaluation of stone disease and VUR [2–5]. It was recently proposed that there is a significant relationship between ureteral jet dynamics and presence of nonobstructive lower pole kidney stones in adult patients suffering from kidney stone disease [6].

However, it is believed that, to date, there is no report regarding this subject in the pediatric population. The present study intended to explore whether the previous findings in adults about the association of ureteral jet dynamics and nonobstructive kidney stones were also valid for the pediatric population.

## Material and methods

This cross-sectional study was carried out between March 2013 and December 2013. The study protocol was approved by the Local Ethics Committee and a written consent form was obtained for each participant. Children aged 4–18 years old and referred to the Urology and Pediatric Nephrology clinics at the Dokuz Eylul University Hospital with flank pain underwent evaluation for stone disease. Group 1 consisted of children with unilateral, nonobstructive, lower pole kidney stones $\leq$1 cm after evaluation for stone disease. Group 2, which served as the control group, comprised healthy children with no evidence of kidney stones on US, within a group of age-matched asymptomatic children who were admitted to the Pediatric clinic for routine check-ups, and healthy children with regular follow-ups with no previous history of urinary tract stone disease with age-matching of $\pm$1 year of age. The age distribution for groups are given in Table 1. All children with a history of previously known metabolic disturbances for stone disease, voiding dysfunctions and other chronic disease (hypertension, diabetes mellitus, hypercholesterolemia, obesity) requiring therapy were excluded. Patients' oxological calculations (percentile and standard deviation score (SDS) levels and body mass indexes (BMI)) were calculated by referencing 2000 data of the Centers for Disease Control and Prevention (CDC) after height and weight measurements were taken. The SDS values of the patients were between $-2$ and $+2$; patients with $<-2$ or $>+2$ SDS values were excluded from the study. All children, including the controls, underwent metabolic evaluation consisting of serum blood sample tests (creatinine, uric acid, calcium and electrolytes), urinalysis (dipstick, microscopy and urine pH level test) and 24-h urine collection test (calcium, citrate, oxalate, uric acid, magnesium and amino acids levels of urine); patients with UTI, any metabolic abnormalities and elevated creatinine level were also excluded. Enrolled children were evaluated by two experienced radiologists blinded to each other. The first radiologist (GU) performed B-Mode US examinations for all children at admission; for the diagnosis of stone disease and the doubtful cases where US examination was unclear because of anatomic and technical reasons, such as abdominal gas distention etc., non-contrast computed tomography (NCCT) was performed for accurate diagnosis. The second radiologist (CA) performed color Doppler US for the evaluation of ureteral jet dynamics in the whole group included in the study.

**Table 1** The age distribution between Group 1 and Group 2.

| Age (year) | Group 1 (n = 32) | Group 2 (n = 32) |
|---|---|---|
| 4 | 3 | 4 |
| 5 | 3 | 3 |
| 6 | 4 | 5 |
| 7 | 3 | 2 |
| 8 | 2 | 3 |
| 9 | 2 | 2 |
| 10 | 2 | 3 |
| 11 | 2 | 2 |
| 12 | 2 | 1 |
| 13 | 2 | 2 |
| 14 | 2 | 2 |
| 15 | 2 | 1 |
| 16 | 1 | 1 |
| 17 | 1 | 1 |
| 18 | 1 | 0 |

**Table 2** Descriptive data of children in Group 1 and Group 2.

| | Group 1 (n = 32) | Group 2 (n = 32) | *P* |
|---|---|---|---|
| Renal units (affected/healthy) | 64 (32/32) | 64 (0/64) | – |
| Stone side (right/left) | 16/16 | – | – |
| Gender (male/female) | 19/13 | 16/16 | 0.451[b] |
| Mean age (years) (min/max) | 9.9 $\pm$ 4.4 (4.3/17.9) | 8.8 $\pm$ 3.1 (4.1/16.5) | 0.285[a] |
| Mean height (cm) (min/max) | 132.1 $\pm$ 22.4 (96/175) | 130.4 $\pm$ 19.0 (100/160) | 0.747[a] |
| Mean weight (kg) (min/max) | 31.7 $\pm$ 14.1 (14/58) | 30.2 $\pm$ 11.1 (15/54) | 0.631[a] |
| Mean BMI (kg/m$^2$) (min/max) | 17.1 $\pm$ 2.6 (13.6/22.5) | 17.1 $\pm$ 2.3 (13.7/22.5) | 0.998[a] |
| Percentile value for mean weight SDS (min/max) | 37.6 $\pm$ 28.4 (−1.47/+1.32) | 47.9 $\pm$ 27.9 (−1.37/+1.73) | 0.150[a] |
| Percentile value for mean height SDS (min/max) | 33.2 $\pm$ 23.1 (−1.52/+1.40) | 43.5 $\pm$ 25.1 (−1.42/+1.83) | 0.092[a] |
| Mean weight for height (min/max) | 102 $\pm$ 12.1 (86.6/134.0) | 103.3 $\pm$ 12.8 (82.1/141.7) | 0.688[a] |

min = minimum, max = maximum, BMI = Body mass index, SDS = Standard deviation score.
[a] *t*-test analysis.
[b] The Pearson Chi-squared test analysis.