Comparison of Ultrasonography and Low-Dose Computed Tomography for the Diagnosis of Pediatric Urolithiasis in the Emergency Department

Acil Serviste Çocuk Hastalarda Üriner Sistem Taş Tanısında Ultrason ve Düşük Doz Bilgisayarlı Tomografinin Karşılaştırılması

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ABSTRACT

Objective: This study aimed to compare ultrasonography (US) and low-dose computed tomography (LDCT) for diagnosing pediatric urolithiasis in the emergency department.

Materials and Methods: This retrospective study was approved by our institutional ethics committee, and informed consent was waived. From March 2016 to March 2017, 100 consecutive patients met the selection criteria and were enrolled in the study. Patients were randomly selected in a 1:1 ratio and were allocated to one of the following two imaging groups: US or abdominal LDCT. LDCT examinations were performed using a 320-detector row CT. Radiation dose analysis was performed using Radimetrics. US examinations were performed using the Aplio 500 ultrasound system. The presence of urolithiasis, anatomical location of urolithiasis, and measurements of renal stones were evaluated and recorded.

Results: There were statistically significant differences between US and standard-dose CT (SDCT) with respect to the diagnosis of urolithiasis, anatomical location of urolithiasis, and measurements of renal stones ($p<0.001$, $p=0.005$, and $p=0.03$, respectively). The mean effective radiation dose of LDCT was 1.44±0.34 mSv and that of SDCT was calculated to be 4.36±1.33 mSv. There was no statistically significant difference between LDCT and SDCT with regard to the diagnosis of urolithiasis, anatomical location of urolithiasis and measurements of renal stones ($p=1$ for all). The diagnostic accuracy of US and LDCT was 0.68 and 1.0, respectively.

Conclusion: Low-dose computed tomography had 1/3 SDCT radiation dose, and LDCT and SDCT accurately diagnosed pediatric urolithiasis in the emergency department. US had a lower accuracy than SDCT and LDCT for diagnosing pediatric urolithiasis in the emergency department. LDCT can be an alternative for SDCT for diagnosing pediatric urolithiasis.

Keywords: Urolithiasis, emergency, ultrasonography, computed tomography, pediatric, radimetrics

ÖZ

Amaç: Bu çalışmamızda acil serviste çocuk hastalarda üriner sistem taş tanısında ultrason (US) ve düşük doz bilgisayarlı tomografinin (DDBT) karşılaştırılması.

Gereç ve Yöntemler: 2016 Mart ve 2017 Mart tarihleri arasında toplam 100 hasta çalışmaya dahil edildi. Hastalar 1e 1e oranında US ve DDBT grubuna seçildi. BT incelemeleri 320 kesitli BT cihazı ile gerçekleştirildir. Radyasyon dozları Radimetrics programı kullanılarak hesaplandı. US incelemeleri Aplio 500 cihazında gerçekleştirildi. Taş varlığı, taş lokalizasyonu ve taş boyutları ölçüldü.

Bulgular: Taş varlığı, taş lokalizasyonu ve taş boyutlarında US ve standard dose BT (SBT) arasında istatistiksel fark vardı ($p<0,001$, $p=0,005$ ve $p=0,03$, sırasıyla). US'nin tanısal başarısı 0,68 ve DDBT'nin tanısal başarısı 1 bulundu. DDBT de ortalama efektif radyasyon doz 1,44±0,34 mSv bulundu. SBT'de ortalama efektif radyasyon doz 4,36±1,33mSv bulundu. Taş varlığı, taş lokalizasyonu ve taş boyutlarında DDBT ve SBT arasında istatistiksel fark yoktu ($p=1$).

Sonuç: Düşük doz bilgisayarlı tomografinin dozu SBT'nin 1/3ü kadardır, DDBT acil serviste çocuk hastalarda üriner system taş tanısında SBT kadar başarılıdır. US, SBT ve DDBTden daha düşük tanısal başarıya sahiptir. DDBT, çocuk hastalarda üriner system taş tanısında SBT ye bir alternatif olabilir.

Anahtar Kelimeler: Ürolityazis, acil servis, ultrason, bilgisayarlı tomografi, çocuk, radimetrics

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Introduction

In the last decades, the incidence of urolithiasis has been increasing in the pediatric population [1, 2]. As a result, both emergency department visits and hospital admissions have increased, with increased costs of medical and surgical treatments [3]. Considering all these increases, the diagnosis of urolithiasis becomes an important part of the pediatric population.

Ultrasonography (US) is the first choice in the diagnosis of urolithiasis because it does not contain ionizing radiation and is cheap. However, the most important limitation is that US is user dependent, and the lower sensitivity for renal stones [1].

Radiography is another imaging modality that is used for diagnosis and follow-up because it is easily available, cheap, and has lower ionizing radiation [2]. However, radiography does not show non-radiopaque and small renal stones and is insufficient in other pathologies such as hydronephrosis.

Computed tomography (CT) is accepted as the gold standard for diagnosing urolithiasis [1]. However, the most important limitation of CT is the presence of ionizing radiation. This limitation is more important when a patient population is a pediatric group. Another limitation is that CT is expensive.

Dual energy CT (DECT) is a new technology that has been developed in recent years and is used in many emergency settings [4-6]. Renal stone types can be identified using DECT, and treatment can be planned accordingly.

In recent years, CT has improved both lowering radiation doses and improving image quality. Thus, it can be accurately diagnosed with much lower radiation doses. In the literature, there has been no study on the pediatric patient group with low-dose CT (LDCT) study with new generation CT.

We aimed to compare US and LDCT for the diagnosis of pediatric urolithiasis in the emergency department.

Materials and Methods

This retrospective study was approved by our institutional ethics committee, and informed consent was waived. From March 2016 to March 2017, 100 consecutive patients met the selection criteria and were enrolled in the study. We included patients aged <19 years who were admitted to the emergency department and for whom imaging modalities were performed to establish or rule out a primary diagnosis of urolithiasis, and established or ruled out a diagnosis of urolithiasis by standard-dose CT (SDCT) or surgery .

Patients were randomly selected in a 1:1 ratio to one of the following two imaging groups: US or abdominal LDCT.

Imaging

Low-dose multidetector CT examinations were performed using a 320-detector row CT (Aquilion One Vision; Toshiba, Otawara, Japan). The scan parameters are given in the Table 1. Radiation dose analysis was performed using Radimetrics (Bayer, Whippany, NJ) [7].

Table 1. Low-dose MDCT protocol parameters

Device	Patient Weight	Mode	Pitch	kVp	mAs
Aquilion One Vision (Toshiba)	<16 kg	Volume	-	80	Automatic*
	16-30 kg	Helical	0.81	80	Automatic*
	31-45 kg	Helical	0.81	80	Automatic*
	46-60 kg	Helical	0.81	100	Automatic*
	>60 kg	Helical	0.81	100	Automatic*

MDCT: multidetector computed tomography; kVp: peak kilovolt; mAs: milliampere-second

*Automatically calculated using scanogram images

Ultrasonography examinations were performed using the Aplio 500 ultrasound system (Toshiba Medical Systems, Otawara, Japan) with a 3.5- to 5-MHz convex probe. The sonographic evaluations were performed by a 7-year-experienced radiologist. US examinations were performed with the patient lying in the supine, right decubitus, and left decubitus positions.

Image analysis

Two radiologists (MK and RS with 10 and 3 years of experience with pediatric radiology, respectively), who were blinded to the clinical data, prospectively and independently reviewed the US and CT images using a workstation (Syngo Via Console, software version 2.1, Siemens AG Medical Solutions, Erlangen, Germany), and discrepancies were resolved by consensus. The presence of urolithiasis, anatomical location of urolithiasis, and measurements of renal stones were evaluated and recorded.

Statistical analysis

Statistical analysis were performed using the Statistical Package for Social Sciences 22.0 software (IBM Corp.; Armonk, NY, USA). One-way analysis of variance and chi-square tests were used to compare the continuous and categorical variables between the two groups. p values of <0.05 were considered to be statistically significant.

Results

There was no significant difference between the LDCT group and the US group in terms of sex and age (p=0.86 and p=0.74, respectively). LDCT and US examinations were performed without any problems.

The mean age of the patients in the US group was 12.44±4.65 (6-18) years. There was no statistically significant difference between the urolithiasis-positive and -negative groups regarding age (p=0.74). Twenty-one patients were females and 29 were males. Renal stones were found in 13 patients (26%). Of the patients with renal stone, five were females and eight were males. There was no statistically significant difference between the urolithiasis-positive and -negative groups regarding sex (p=0.85). The mean stone long axis was 7.5±4.49 (4-16) mm. There were eight renal stones in one patient, two in three patients, and three or more in two patients. Two patients had renal stones in the lower pole of the right kidney, three in the middle zone of the right kidney, one in the middle zone of the left kidney, one in the upper pole of the right kidney, four in the right proximal ureter, one in the right distal ureter, three in the left proximal ureter, and two in the left distal ureter (Figure 1, 2). In three patients, the diagnosis of urolithiasis was confirmed by surgery. Forty-seven patients were diagnosed using SDCT. The mean effective radiation dose of SDCT was calculated to be 4.28±1.33 (2.56-6.84) mSv. There was a statistically significant difference between US and SDCT for the diagnosis of urolithiasis, anatomical location of urolithiasis, and measurements of renal stones (p<0.001, p=0.005, and p=0.03, respectively).

The mean age of the patients in the LDCT group was 11.46±4.61 (6-18) years. There was no statistically significant differences between the urolithiasis -positive and -negative groups regarding age (p=0.66). Twenty-three patients were females and 27 were males. Renal stones were found in 22 patients (44%). Of 22 patients with renal stones, 10 were females and 12 were males. There was no statistically significant difference between the urolithiasis-positive and -negative groups regarding sex (p=0.985). The mean renal stone long axis was 6.4±4.29 (1-18) mm. There were nine renal stones in one patient, two in five patients, and three or more in eight patients. Four patients had renal stones in the lower pole of the right kidney, five in the lower pole of the left kidney, five in the middle zone of the right kidney, five in the middle zone of the left kidney, four in the right kidney upper pole, one in the upper pole of the left kidney, five in the right proximal ureter, four in the right distal ureter, two in the left proximal ureter, and two in the left distal ureter (Figure 3, 4). In one patient, a renal stone was observed in the bladder (Figure 5). The mean effective radiation dose of LDCT was 1.44±0.34

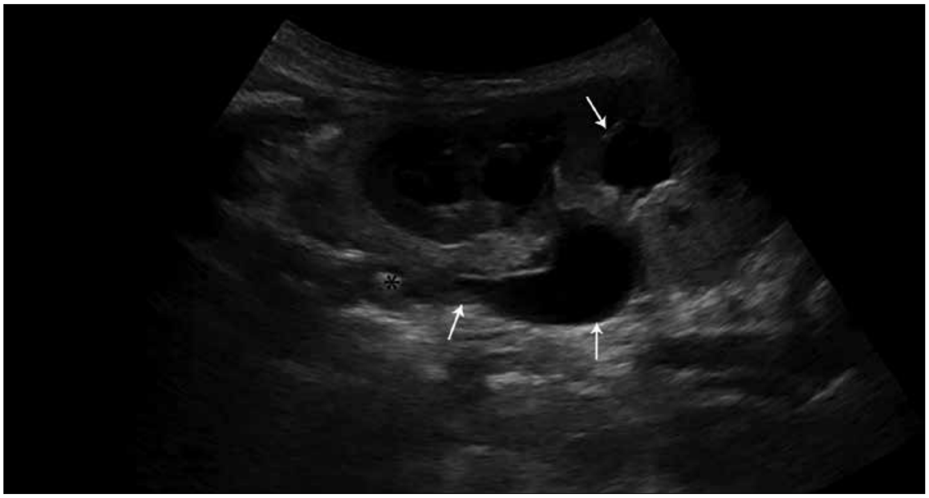

Figure 1. Ultrasound image of a 10-year-boy shows echogenic renal stones (asterisk) in the proximal ureter. There was grade 2 hydroureteronephrosis (arrows) because of renal stone obstruction.

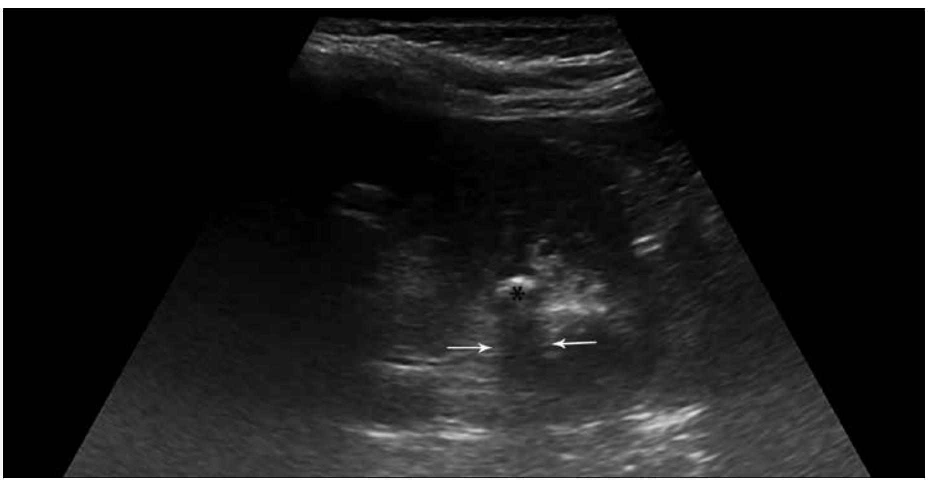

Figure 2. Ultrasound image of a 7-year-girl shows echogenic renal stones (asterisk) in the lower pole of the left kidney. There was a shadowing (arrows) as a result of the renal stones.

Figure 3. Axial LDCT image of a 17-year-old girl shows renal stone formations in the bilateral renal calyx (arrow). The effective radiation dose for this examination was 1.81 mSv.
LDCT: low-dose computed tomography

(0.8-2.5) mSv. In eight patients, the diagnosis of urolithiasis was confirmed by surgery. Forty-two patients were diagnosed using SDCT. The mean effective radiation dose of SDCT was calculated to be 4.36±1.33 (2.68-6.9) mSv. There was no statistically significant difference between LDCT and SDCT for the diagnosis of urolithiasis, anatomical location of urolithiasis, and measurements of renal stones (p=1 for all).

Discussion

Compared with the literature, our study reports the lowest radiation dose in pediatric patients for diagnosis of urolithiasis [3, 8-10]. It contains the largest pediatric patient population in the literature. The success of LDCT in our study was found to be the same as that of SDCT and that of US is similar to that reported in the literature [8-11]. US is the first preferred imaging modality. In addition, LDCT is an important method that could be used when US is not sufficient.

In our study, the diagnostic accuracy of US was similar to that reported in the literature [3, 12]. However, US fault to show small-sized renal stones.

In our study, the diagnostic accuracy of LDCT in urolithiasis diagnosis was similar to the literature [8-11]. Malkawi et al. [8] showed low diagnostic accuracy in showing LDCT in ureteral stones in their studies. In our study there was no difference between LDCT and SDCT. Sohn et al. [9] compared LDCT and SDCT in stone measurements in patients with stone and there was no difference in stone measurements in both groups. Their findings are consistent with our study. The mean LDCT dose is 6.2 mSv, which is even higher than that of our study [10]. Standard doses of CT protocol are less than half of our studies in literature [1, 3, 8, 9]. This is due to the fact that they are based on fixed use of mAs, due to the fact that they are not able to use auto mAs value according to scanogram because it is old technology. In addition, our low-dose CT protocol doses were as diagnostic as standard doses of approximately 10% of the literature [3, 8, 10].

Smith-Bindman et al. [3] compared US and CT in their study of adult patients who had been referred to the emergency service and found that the total dose in each group was over 10 mSv. In our study, the LDCT group had a low rate of 1.44 mSv. It should be kept in mind that additional doses and radiation dose may increase when US patients cannot be diagnosed.

Our study had several limitations. The first was that the patient count was low. We hope to have more accurate results with studies involv-

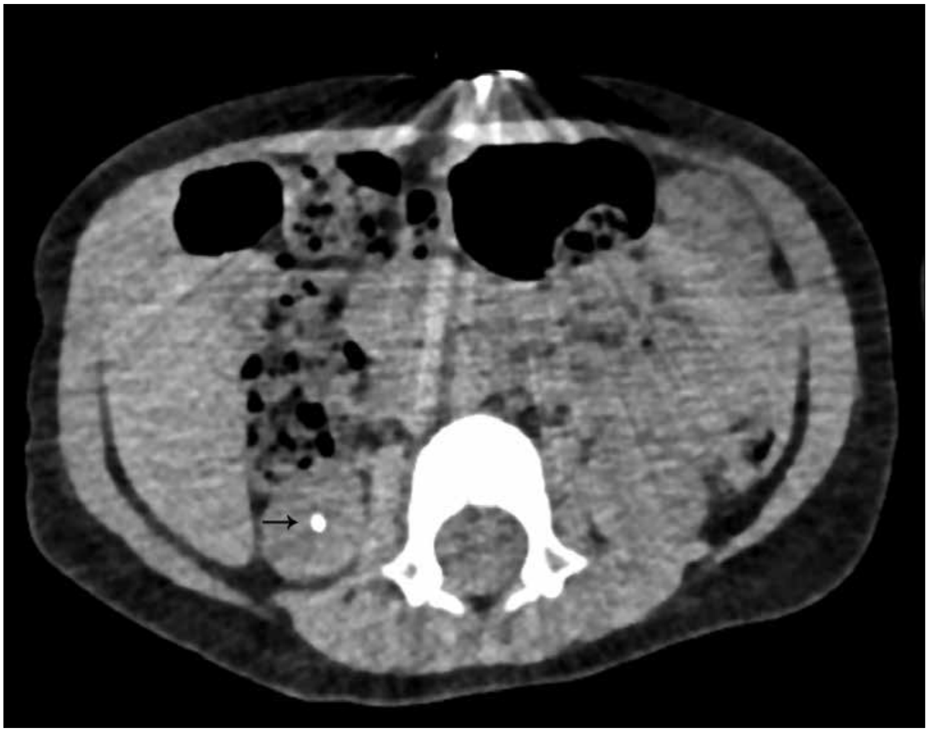

Figure 4. Axial LDCT image of a 3-year-old boy shows renal stones in the right kidney (arrow). The effective radiation dose for this examination was 0.92 mSv.
LDCT: low-dose computed tomography

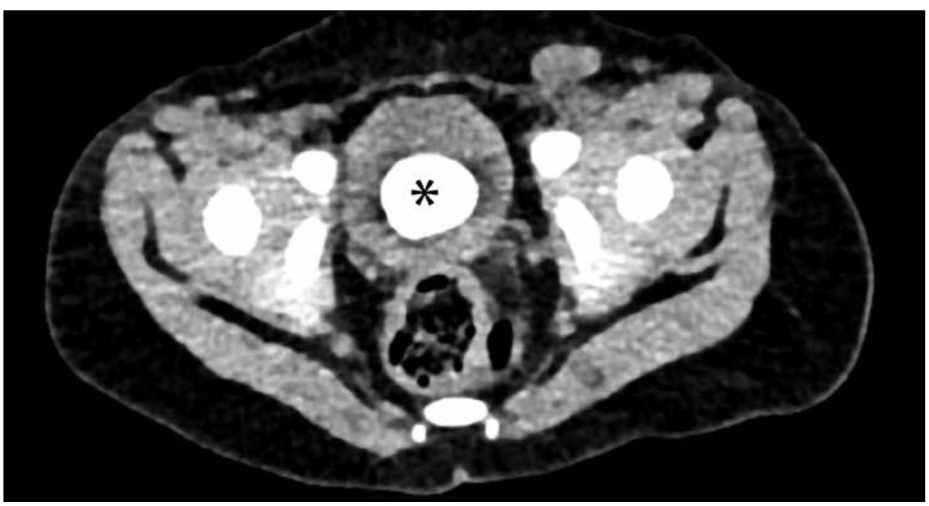

Figure 5. Axial LDCT image of a 2-year-old toddler shows renal stones in the urinary bladder (asterisk). The effective radiation dose for this examination was 0.95 mSv.
LDCT: low-dose computed tomography

ing more patients. Secondly, US and LDCT did not apply to the same patient. There is a statistically significant difference between age and sex distribution between the two groups. A study on the same patients would be more accurate.

In conclusion, LDCT is as successful as SDCT in the diagnosis of pediatric urolithiasis and approximately the same result can be obtained with one third standard dose. US still maintains his position in diagnosis of urolithiasis. LDCT should be used instead of SDCT in patients in whom the US is inadequate.

Ethics Committee Approval: The ethics committee approval was received for this study from institutional ethics committee.

Informed Consent: Informed consent is not necessary due to the retrospective nature of this study.

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