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Predicting the stone composition of children preoperatively by Hounsfield unit detection on non-contrast computed tomography

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Summary

Introduction
Many studies have been performed on adult patients to reveal the relationship between Hounsfield unit (HU) value and composition of stone, but none have focused on childhood.

Objective
We aimed to predict stone composition by HU properties in pre-intervention non-contrast computed tomography (NCCT) in children. This could help to orient patients towards more successful interventions.

Materials and methods
Data of 94 children, whose pre-intervention NCCT and post-interventional stone analysis were available were included. Stones were grouped into three groups: calcium oxalate (CaOx), cystine, and struvite. Besides spot urine PH value, core HU, periphery HU, and Hounsfield density (HUD) values were measured and groups were compared statistically.

Results
The mean age of patients was 7 ± 4 (2—17) years and the female/male ratio was 51/43. The mean stone size was 11.7 ± 5 (4—24) mm. There were 50, 38, and 6 patients in the CaOx, cystine, and struvite groups, respectively. The median values for core HU, periphery HU, and mean HU in the CaOx group were significantly higher than the corresponding median values in the cystine and struvite groups. Significant median HUD difference was seen only between the CaOx and cystine groups. No difference was seen between the cystine and struvite groups in terms of HU parameters. To distinguish these groups, mean spot urine PH values were compared and were found to be higher in the struvite group than the cystine group (Table).

Discussion
The retrospective nature and small number of patients in some groups are limitations of this study, which also does not include all stone compositions. Our cystine stone rate was higher than childhood stone composition distribution in the literature. This is because our center is a reference center in a region with high recurrence rates of cystine stones. In fact, high numbers of cystine stones helped us to compare them with calcium stones more accurately and became an advantage for this study.

Conclusions
NCCT at diagnosis can provide some information for determination of stone composition. While CaOx stones can be discriminated from cystine and struvite stones using HU parameters, a simple spot urine pH assessment must be added to distinguish cystine stones from struvite stones.

Table Comparison of stone types according to HU parameters, spot urine PH, and *p* values.

	Parameters				
	Core HU	Periphery HU	Mean HU		Spot urine PH
CaOx vs Cyst	**<0.001**	**<0.001**	**<0.001**	CaOx vs Cyst	0.376
CaOx vs Strv	**0.039**	**0.045**	**0.028**	CaOx vs Strv	0.111
Cyst vs Strv	0.598	0.956	0.760	Cyst vs Strv	**0.039**

Significant values to distinguish groups are in bold.
CaOx, calcium oxalate; Cyst, cystine; Strv, struvite.

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Introduction

As in adults, non-contrast computed tomography (NCCT) is the imaging method with highest sensitivity used in diagnosis of urolithiasis in children [1,2]. Also it gives detailed information about the anatomy and location of the stone that helps in preoperative planning for different types of interventions. In pediatric patients, there is a known relation between shock-wave lithotripsy (SWL) success rates and the Hounsfield unit (HU) values of stones in the NCCT evaluation [3]. Many studies have been performed in adult patients to reveal the relationship between HU value and composition of stone [4–11], but none have yet focused on the childhood period. Knowledge about the composition of the stone can help when choosing the intervention modality likely to be most suitable and successful. The aim of this study was to investigate the predictive ability of the HU measurement on the stone's physical composition in children.

Materials and methods

Data of patients under 18 years old who underwent percutaneous nephrolithotomy (PCNL) and SWL between January 2008 and December 2014 were evaluated retrospectively. Ninety-four patients with stones $\geq$4 mm, with both pre-intervention NCTT and post-intervention stone physical analyses results available were included. We included stones bigger than 4 mm to measure HU values clearly from different parts of the stones with a region of interest of 1 mm^2. The patients' first visit spot urine pH values were recorded.

All patients had NCCT (Sensation 16, Siemens, Germany) using 3–5 mm sections, at 100 kV and 30–120 mAs, according to weight, prior to treatment. The longest dimension of each stone in transverse sections was accepted as stone size (mm). Stone volume was calculated by multiplying the width (mm) of the stone measured from the same section and stone depth measured from the coronal section (volume $=$ length $\times$ width $\times$ depth $\times$ π $\times$ 0.167) by multiplanar reconstruction [12]. The HU attenuation of each stone was measured by a region of interest (ROI) of 1 mm^2 in the NCCT image with the largest stone size. It was performed once at the centre (core HU) and twice at each edges (edge HUs). An average of two edges' HU was accepted as periphery HU. Mean HU was determined by calculating the average of core HU and periphery HU. HU density (HUD HU/mm) was calculated by dividing mean HU by stone size [13] (Fig. 1). Calculations were performed in the bone window. Radiological evaluation was performed by two radiologists (MH, AG) who were blinded to the composition of the stones.

Stones were grouped into three groups, calcium oxalate (CaOx), cystine, and struvite, according to their x-ray diffractometry results. The CaOx group consisted of calcium oxalate monohydrate (CaOMH) and mixed (calcium oxalate mono and dihydrate) stones. The three groups were compared according to stone size, stone volume, core HU, periphery HU, mean HU, HUD, and spot urine pH parameters.

Correlation between two variables was investigated using Spearman correlation analysis. The HU values of two groups which were distributed parametrically were compared using the *t* test and two groups which were non-parametrically distributed were compared using the Mann–Whitney U test. The Kruskal–Wallis Dunn test was used to compare the HU values of more than two groups that are distributed non-parametrically. The level of significance was set at $p < 0.05$. Receiver operating characteristics (ROC) analysis was used to calculate cut-off HU values for each group. Statistics were performed using IBM SPSS 22.0 software (SPSS Inc. Chicago, IL, USA).

Results

The mean age of patients was 7 $\pm$ 4 (2–17) years and the female/male ratio was 51/43. The mean stone size was 11.7 $\pm$ 5 (4–24) mm and the mean stone volume was found to be 754 $\pm$ 419 (33–4530) mm^3. Fourteen (15%) patients underwent SWL, while PCNL was performed in 80 (85%) patients. There were 50, 38, and 6 patients in the CaOx, cystine, and struvite groups, respectively. The CaOx group consisted of 24 CaOMH and 26 mixed stones.

Core HU measurements had no correlation with stone size and stone volume (Spearman correlation test, $r = 0.156$, $p = 0.133$ and $r = 0.067$, $p = 0.523$, respectively). Periphery HU had no correlation with stone size (Spearman correlation test, $r = 0.183$ and $p = 0.077$). However, periphery HU measurements had positive correlation with stone volume (Spearman correlation test, $r = 0.237$, $p = 0.022$).

There was no significant difference between CaOMH and mixed subgroups of CaOx stones; in terms of core HU

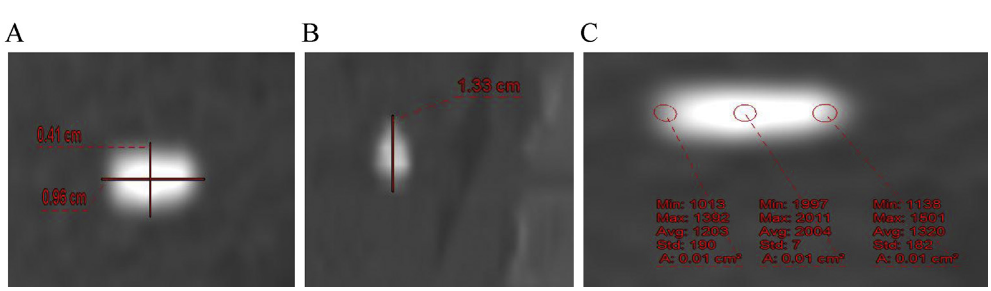

Figure 1 Measurement of the longest dimension of the transverse section of the stone (A). Measurement of depth of stone in the axial section (B). Measurement of core HU and both edges HU of the stone (C). Periphery HU value can be obtained by the average of the values measured by both edges. Mean HU value can be obtained by the average of periphery HU and core HU values.

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