The efficacy of Hounsfield units in diagnosis of urinary stones prior to percutaneous nephrolithotomy (PCNL) in pediatric population

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Background:

The advancement of ureteroscopy, has altered the management of urinary tract stones. Many parameters, including stone size, stone placement, multiplicity, and Hounsfield Unit (HU) values evaluated by non-contrast computed tomography, have been found to predict stone free outcome. Furthermore, a lot of research have been conducted to determine the curative threshold of HU.

Objective:

To evaluate the usefulness of Hounsfield unit and density in the assessment and treatment of urinary stones in pediatric population presented with renal stones.

Methodology:

This is a retrospective, cross sectional study. Demographic details such as age, gender, positive family history, previous renal stone history and stone characteristics such as stone size, stone site, stone location, hydronephrosis, and hyderoureter were documented. Hounsfield units were recorded from CT data, post-operative stone analysis, stone clearance, duration of surgery and stone free rates were also noted. For the link between proportional variables, Pearson correlation analysis was utilized. The HU cutoff value, which enhances the likelihood of being stone-free, was identified using receiver operating characteristics (ROC) analysis. P value < 0.05 was regarded as statistically significant.

Results:

The mean age of included patients was 8.5 ± 4.9 years with range of 4 – 14 years. The laterality of stone location was reported as almost similar on both sides with 85 (%) on right side while 82 (%) on left side with insignificant p-value of 0.28. The association of stone composition and HU quantity dictating maximum require HU for CAP 4(%), COM 8(%) and UA + COM 6(%) compositions.

Conclusion:

According to our study results, the HU values can be used to predict a few stone compositions including AHU, COM and UA+COM especially in pediatric population.

Keywords:

Hounsfield units, CT KUB, PCNL, Pediatric renal stone

INTRODUCTION:

Percutaneous nephrolithotomy (PCNL) is a well-known and successful treatment that has been used for a long time to treat large or complex kidney stones with higher success rates than other minimally invasive methods.[1] Fluoroscopic imaging is routinely utilized in PCNL procedures to access the renal collecting system, assess renal anatomy, ensure adequate tool placement, and observe and locate leftover stones.

The recent advancement of ureteroscopy, in particular, has changed the treatment of urinary tract stones. ESWL has the advantages of simplicity and non-invasiveness, failure of a first ESWL effort, on the other hand, necessitates a follow-up ESWL treatment or an alternate procedure, both of which raise medical costs.[2-3] Given the foregoing, it is critical to identify patients for whom ESWL might be most useful prior to therapy. Many parameters, including stone size, stone placement, multiplicity, and Hounsfield Unit (HU) values evaluated by non-contrast computed tomography, have been found to predict stone free outcome. Furthermore, a lot of research have been conducted to determine the curative threshold of HU.[4-5] Calcium oxalate monohydrate and cysteine stones are both resistant to shockwave lithotripsy. Understanding stone composition is thus vital in treatment, however it is difficult before treatment. Some investigations have found that urinary stone HU values can predict stone composition.

These rates are influenced by factors such as the weight and location of the stone. Viewing residual stones with fluoroscopy is highly reliant on the opacity and size of the stone. The Hounsfield unit (HU) values found in the unenhanced CT have been linked to the visibility of stones on plain radiography and may predict the result of shockwave lithotripsy (SWL).[6]

The use of non-contrast computed tomography (CT) in patients with urinary system stones has expanded in recent years. Hounsfield units (HU), a basic CT characteristic, are connected to the density of the stone or structure of interest.[7] Sir Godfrey New bold Hounsfield established the radio density scale after originally introducing the principle to quantify the amount of X-rays that pass through or are absorbed by tissues. CT scans are made up of pixels, each with a grey scale value ranging from 1 (black) to 256. This figure represents the number of X-rays that pass through the structure and is measured and given in Hounsfield units (HU). Since then, HU has been utilized to analyze and quantify tissues and fluids.[8] The CT density of urinary system stones can also be assessed by HU. This has become an essential diagnostic technique in recent years, not only for predicting the type of stone but also for defining the best manner of therapy. Urologists can use the radio-opacity of urinary system stones to determine the best treatment and imaging modality for their patients during follow-up.[9] Nonetheless, the association between the range/threshold of HU values obtained with CT and radio-opacity remains unknown. Using CT to identify radiolucent stones has the advantage of avoiding unnecessary radiographies during follow-up, avoiding radiation exposure, minimizing anxiety, and saving costs. Taken together, data examining the link between HU values and radio-opacity revealed that certain groups of patients might be adequately followed up on using plain radiographs rather than repeated CT exams, saving time, money, and ionizing radiation exposure.[10]

This study aims to evaluate the Usefulness of Hounsfield unit and density in the assessment and treatment of urinary stones in pediatric population presented with renal stones.

METHODOLOGY:

We reviewed the data of 250 pediatric patients retrospectively who underwent unilateral percutaneous nephrolithotomy to remove renal stone in our institute, however only 167 had CT KUB along with other radiological investigations for diagnostic purposes and been included in the study. Demographic details such as age, gender, positive family history, previous renal stone history and stone characteristics such as stone size, stone site, stone location, hydronephrosis, and hyderoureter were documented. Hounsfield units were recorded from CT data, post-operative stone analysis, stone clearance, duration of surgery and stone free rates were also noted. Urinalysis and bacteriologic analysis, whole blood count, serum biochemistry, and coagulation tests were performed on all patients prior to the surgery. The HU values of each stone were computed in our institution using an unenhanced CT scan (Siemens Somatom Emotion Duo) utilized in renal stone protocols. The average HU values were calculated using the largest available circular diameters. The European Association of Urology created rules for calculating stone sizes based on stone surface area.

The stones were classified as single calyx, renal pelvis, pelvis + single calyx, or staghorn (present in multiple calyxes). Because there are no objective criteria in the literature used to define stone opacity.

After administering general anesthesia, 6F open-ended ureteral catheters were implanted in all patients in the lithotomy position to view the anatomy of the collecting system during the PCNL surgery. Following that, all patients were returned to the prone position, and the collecting system was examined using fluoroscopy and radio contrast media. Percutaneous entry was thus obtained. The tract was dilated with Amplatz dilators. A 26F Nephroscope was employed for the nephroscopy technique, and a pneumatic lithotripter was used for in vivo lithotripsy. Fluoroscopic imaging and Antegrade nephrostography were used intraoperative to assess the presence of residual stones and the integrity of the collecting system.

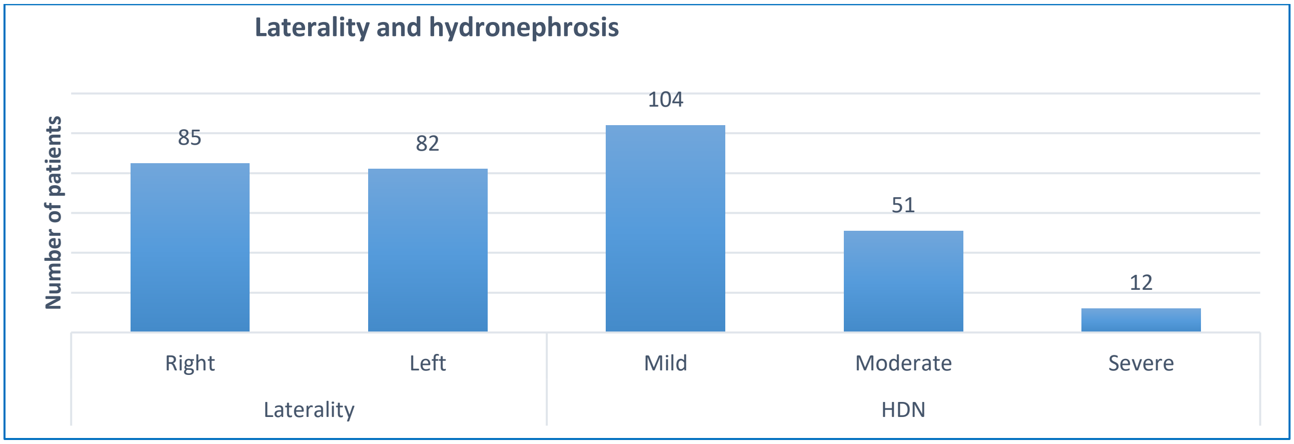
In the third month after surgery, all patients were examined using intravenous urography, ultrasonography (US), or an unenhanced CT scan. If the patient was either stone-free or had only a clinically minor remnant fragment (residue 4 mm), the treatment was judged successful. The X-ray diffraction method was used to analyses the stone. Statistical analyses were carried out with the aid of commercially available software Statistical package of social sciences (SPSS) version 22. In addition to the frequency and percentage distributions of the data, the Student t test and the chi square test were used to compare groups, and the chi square test was used to compare variables between categorical data.

For the link between proportional variables, Pearson correlation analysis was utilized. The HU cutoff value, which enhances the likelihood of being stone-free, was identified using receiver operating characteristics (ROC) analysis. P value < 0.05 was regarded as statistically significant.

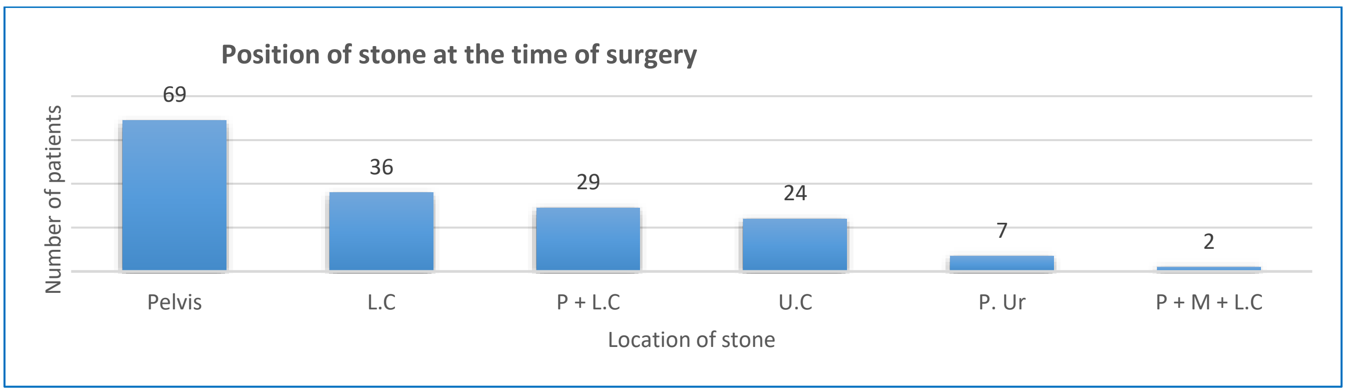
RESULTS:

Total 167 patients were included in the study, included both genders with slight dominance to male children reporting 96 boys (57.5%) and 71 girls (42.5%). The mean age of included patients was 8.5 ± 4.9 years with range of 4 – 14 years. The laterality of stone location was reported as almost similar on both sides with 85 (50.8%) on right side while 82 (49.1%) on left side with insignificant p-value of 0.28. the most frequently reported degree of hydronephrosis is mild in 104 (62.2%) followed by moderate hydronephrosis in 51 (30.5%) while severe hydronephrosis was only reported in 12 (7.1%) patients. (Fig 01)

Fig 01: Laterality of stone location and hydronephrosis degree reported pre-operatively.

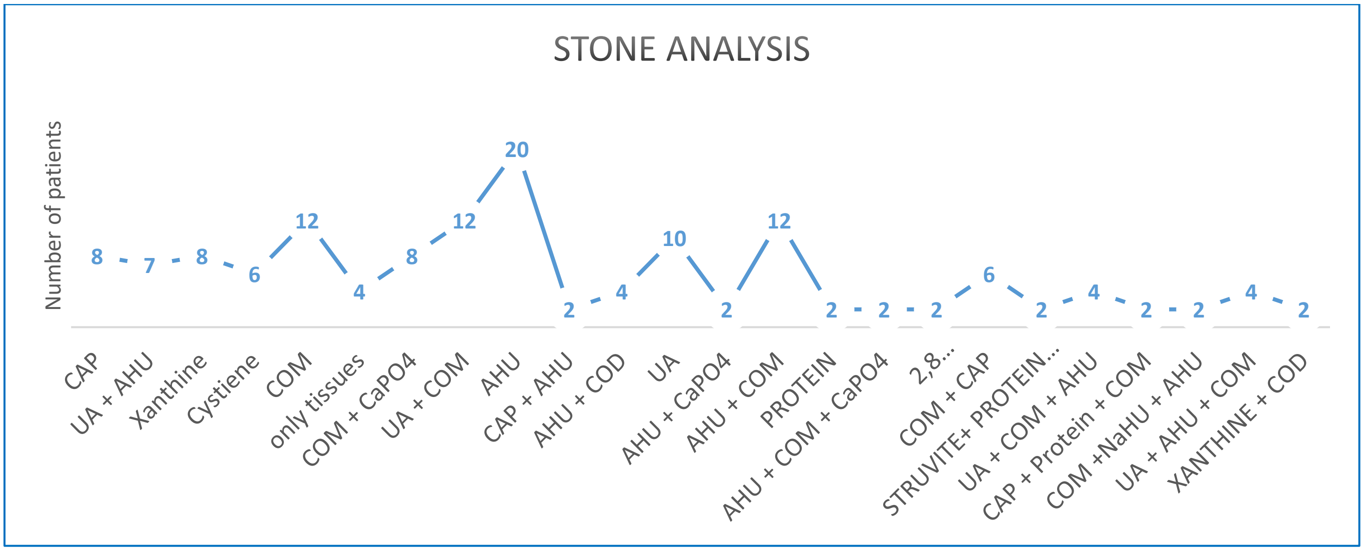


Patients were distributed according to the reported position of stone confirmed in CT KUB, maximum stones were in renal pelvis with 69 (41.3%) while lower calyx stones were reported in 36 (21.5%) of patients. Stones located on multiple calyx were reported as pelvis and lower calyx and pelvis, mid and lower calyx in 29 (17.3%) and 2(1.1%) patients. Proximal ureter stones were reported in 7(4.1%) while upper calyx stones were in 24 (14.3%). (Fig 02)



The reported stone free rates were 154 (92.4%) with complete stone removal while 13(7.7%) reported residual stones on follow-up scans. Stone analysis reports indicated several type of compositions, including ammonium hydrogen urate (AHU) in 20 (11.6%) patients followed by calcium oxalate monohydrate 12(7.1%), combination

Fig 03: Stone composition analysis of patients.



Patients were categorized within three groups according to the HU values used, < 500 HU, 501-1000 and > 1000 reported maximum HU used in Lower calyx 9(5.3%) and upper calyx stone 7(4.1%). While 501-1000 HU were used in mostly patients. The p-value is reported as 0.18. (Table 0

Table 01: Association of stone location with HU.

HU	Stone Location							
	Pelvis	Lower calyx	Pelvis + Lower Calyx	Upper calyx	Kidney + Pro. Ureter	Pelvis + Mid Calyx	Renal pelvis+ mid & lower calyx	P-Value
< 500	15	7	3	5	2	0	0	0.18
501- 1000	48	20	16	12	3	8	2	
> 1000	6	9	1	7	2	1	0	

Similarly, the HU were evaluated with stone size measurements indicating maximum HU usage in 1.1 – 2.0 cms of stone sizes, while the maximum stone measurement > 3.0 cms used >1000 Hu, the p-value is significant with 0.02. (Table 02)

Table 02: Association of stone size with HU.

HU	Stone size (cms)				
	< 1.0	1.1 - 2.0	2.1 - 3.0	> 3.0	P-Value
< 500	2	25	5	0	0.02
501- 1000	0	88	21	0	
> 1000	0	6	15	5	

The association of stone composition and HU quantity has been reported in table 03 indicating maximum require HU for CAP 4(2.3%), COM 8(4.7%) and UA + COM 6(3.5%) compositions. While 201-1000 HU were required in all compositions presented ion study participants including CAP 4(2.3%), UA+AHU 6(3.5%), Xanthine 2(1.1%), Cysteine 4(2.3%), COM 4(2.3%), COM + CaPO4 6(3.5%), UA+COM 6(3.5%), AHU 14(8.3%), UA 8(4.7%) and AHU+COM 9(5.3%) respectively. The p-value is highly significant (0.01). Table 03

Table 03: Association of stone composition with HU.

HU	Stone analysis											
	CAP	UA + AHU	Xant	Cyst	COM	COM + CaPO4	UA + COM	AHU	AHU + COD	UA	AHU + COM	COM + CAP	P-Value
< 500	0	1	6	0	0	2	0	6	2	2	1	1	0.01
501- 1000	4	6	2	4	4	6	6	14	2	8	9	3	
> 1000	4	0	0	2	8	0	6	0	0	0	2	2	

DISCUSSION:

CT is the most sensitive and accurate imaging modality for detecting urinary calculi at the moment. Because it is noninvasive, it can be used to detect radiolucent and tiny stones, as well as other disorders affecting the urinary tract or other organs.[11] several studies have used CT to estimate the composition and fragility of stones using characteristics like HU, SSD, and stone size. Understanding the makeup of urinary system stones is essential for selecting the best treatment method. Urine pH, crystal presence, plain radiography, and a history of urinary stones have long been used to predict stone composition; lately, HU was also utilized for this purpose. In vitro testing revealed that stone composition may be predicted with great accuracy using HU. Sought to estimate stone composition using HU density, computed by dividing HU by the stone's largest transverse diameter (in mm), and concluded that HU density was more effective than HU alone.[12-13]

The goal of this study was to look at the relationship between HU values and PCNL outcomes while keeping in mind that visibility in fluoroscopy reduces as stone density lowers.[14] In a similar study, the authors reported that calcium stones could be detected with high accuracy using HU values, but that the HU values of cysteine and uric acid stones overlapped, making differentiation difficult.[15] According to recent research, HU and its variations can be used to forecast the composition of stones. However, they were insufficient for certain forms of stones; in such circumstances, the use of urine parameters enhanced the accuracy. In the absence of acute renal colic, infection, or obstruction, medical expulsive treatment (MET) is often employed to facilitate the transit of ureteral stones.[16-17] the spontaneous passing rates can reach 98%, especially in stones smaller than 5 mm. The size and position of the stone are the most crucial elements influencing spontaneous transit. As a result, more research including stones with a broader range of HU values would significantly contribute to current knowledge. Nonetheless, the existing data indicate that HU values offer no further benefit to MET.[18-20]

The position of the stone has been shown to be a major predictor of PCNL outcome. While previous studies have focused on the calyces or renal pelvis, or the proximal, middle, and lower ureters, our investigation looked at both renal and proximal ureter stones. We discovered substantial variations in clearance rates between calyceal stones and proximal stones. [21-24]

Many studies have attempted to analyze stone composition with HU measurements. According to certain studies, stones can be categorized as uric acid, calcium oxalate, or calcium phosphate, retrospective design of our research enabled us to assess all available stone compositions and assess the effect of HU with it. [25-27]

CONCLUSION:

According to our study results, the HU values can be used to predict a few stone compositions including AHU, COM and UA+COM especially in pediatric population. However, Stone location has no significance indicating no positive association of stone location with HU.

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