VOLUME-8, ISSUE-10, OCTOBER-2019 • PRINT ISSN No. 2277 - 8160 • DOI : 10.36106/gjra

Original Research Paper

General Surgery

RELATIONSHIP BETWEEN ABDOMINAL NON-CONTRAST CT SCAN HOUNSFIELD UNIT VALUE WITH STONE COMPOSITION ANALYSIS IN KIDNEY STONE PATIENTS

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ABSTRACT

INTRODUCTION: Hounsfield unit (HU) is used to indicate the radiodensity of urinary stones. Our study aims to describe the relationship between HU with urinary stone.

MATERIAL METHODS: A retrospective cross-sectional study was conducted with thirty patients with kidney stones that have examined with NCCT.

RESULTS: The mean age of patients was 51.0 + 10.4 years, with 15 patients were male (50%), and 15 others were female (50%). The median value of HU level was 661 (range 200-1499). Thirty patients in our study, 16 stones (53.3%) were composed calcium, while 14 others (46.7%), were composed mostly of uric acid. ROC analysis that HU criteria to predict stone composition have sensitivity 71,4% specificity 87,5% PPV 83.33% and NPV 77.78%.

CONCLUSION: The threshold of 500 HU on the CT scan determined as the optimal cut-off point in deciding whether a urinary stone composition is predominantly calcium stone or uric acid stone.

KEYWORDS : Hounsfield Unit, Ncct, Calcium Stone, Uric Acid Stone

INTRODUCTION

Urinary stones seem very common disease burden in the world with the incidence of 10% in developed world and this number even approaching 37% in certain places, with geographical condition, ethnicity, diet, and genetic factor play an important role for urinary stone disease.

Urinary stones usually can be detected with X-ray because of the common calcium composition in most of urinary stone, with non-contrast CT-scan (NCCT) being the gold standard diagnostic procedure for detecting urinary stones.[1] Because of calcium composition in most of urinary stone, Chua et al. were trying to evaluate the stone radiopacity character as Hounsfield Unit (HU) using NCCT. They assumed stone $\geq$ 4 mm have 498.5 HU as the threshold to describe an urinary stone as radiopaque or radiolucent with 89.3% sensitivity and 87.3% specificity.[2] Huang et al. described that stone with density > 800 HU can be visualized clearly at X-ray, on the other hand, urinary stones with < 200 HU cannot be seen in X-ray.[3] Spettel et al also use HU for predicting uric acid stone. They utilize HU and urinary pH as predictor whether urinary stone composed by uric acid. They concluded urinary stone that has $\geq$ 4 mm size, < 500 HU and < 5.5 pH have 90% positive predictive value for having uric acid component as its forming substance.[4]

This study aims to describe relationship between HU with urinary stone analysis outcome in kidney stone patients. We also try to assess the possibility of HU as urinary stone composition predictors.

MATERIAL AND METHODS

A retrospective cross-sectional study was conducted in Universitas Sumatra Utara Hospital from March to August 2018. We enrolled 30 patients with kidney stones that have been examined with NCCT. Demographic data from each patients were collected and summarized. All NCCT scans were interpreted by the same urologist. Bone window settings were used in visualizing the stones. The longest diameter of the stone was measured in milimeters to describe the stone size. Then the stones' HU was calculated automatically from the acquired images.

The patients then had operative treatment for their urolithiasis. Post-operative extracted stone than had stone composition analysis characterization done in laboratory setting as the gold standard. While urinary pH was not collected in our study.

Statistical analysis was done by SPSS 23.0 (IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.). Receiver operating characteristics (ROC) curve was constructed with 500 HU value as the cut off value. Finally, the sensitivity, specificity, positive predictive value and negative predictive value of the NCCT with 500 HU cut-off level were used as a diagnostic tool to predict stones composition. All data analyses were conducted at the 0.05 level of significance and 95% confidence interval.

RESULT

From March to August 2018, there were 30 patients with urolithiasis that diagnosed both by NCCT and KUB (Kidney Ureter Bladder) X-ray. All of these patients undergone urinary stone extraction either by open lithotomies procedures or by endoscopic (percutaneous nephrolithotomy or PCNL). All the extracted stone than analyzed for its composition in laboratory.

The mean age of patients was 51.0 $\pm$ 10.4 years, with 15 patients were male (50%) and 15 others were female (50%). Stone extraction was done with open procedures in eight patients (26.7%) and PCNL in 22 patients (73.3%). The median value of HU level was 661 (range 200-1499).

Table 1. Characteristics of study subjects

Variables	N (%) Mean $\pm$ SD, median (min-max)
No. of patients	30
Age (years)	51.0 $\pm$ 10.4
Gender	
Male	15 (50%)
Female	15 (50%)
Stone extraction procedures	
Open procedures	8 (26.7%)
PCNL	22 (73.3%)
Houndsfield unit	661 (200-1499)

In our study, 16 stones (53.3%) were composed predominantly

by calcium, three stones composed of pure calcium oxalate monohydrate, 12 stones of mixed-predominantly calcium oxalate monohydrate, and one calcium phosphate stones.

On the other hand, 14 others stone that analyzed in this study (46.7%), were composed predominantly by uric acid, with 7 stones were pure uric acid and 7 stones were mixed-predominantly uric acid.

Table 2. Composition of extracted renal stones

Stone Composition	Mean Age (y)	Mal	N (%)	Median (min-
Predominantly uric acid	55.6	57.1	14 (46.7)	440.7 (200-699)
Pure uric acid			7 (23.3)	
Mixed-predominantly uric acid			7 (23.3)	
Predominantly calcium	46.2	43.8	16 (53.3)	941.6 (460-1499)
Pure calcium oxalate monohydrate			3 (10)	
Mixed-predominantly calcium oxalate monohydrate			12 (40)	
Pure calcium oxalate dehydrate			0	
Mixed calcium oxalate dehydrate			0	
Calcium phosphate			1 (3.3)	

From receiver operating characteristics curve we concluded that HU criteria alone to predict stone composition either calcium dominant or uric acid dominant gave sensitivity and specificity of 71,4% and 87,5% respectively. HU also gave PPV of 83.33% and NPV of 77.78%.

Table 3. Receiver operating characteristics analysis

Hounsfield Unit Cut	AUC	Threshold	Sensitivity	Specificity	PPV	NPV
HU	0.931	< 500	71,4%	87,5%	83,33%	77,78%

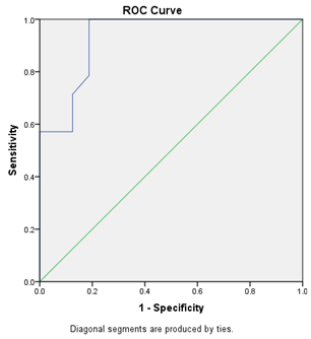

Figure 1. Area Under the Curve

Table 4. Result Variable(s): HU

Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
.931	.045	.000	.843	.000

The test result variable(s): HU has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.
a. Under the nonparametric assumption
b. Null hypothesis: true area = 0.5

DISCUSSION

Demographic data from our study are comparable to the global picture of kidney stone prevalence and incidence, with a peak incidence of urinary stone is occur in 50-60 years of age. The 1: 1 male-female ratio described in our study differs from other Asia-based study conducted by Shirazi et al.[5] and Michaels et al.[6], with a ratio of male and female was 1.98:1 and 1.8:1 respectively. This gender difference can be attributed to the protective effect of estrogen on stone formation in pre-menopausal women under the age of 45 years. Estrogen will improve kidney calcium absorption and it also will reduce bone resorption. This metabolic mechanism will cause a reduction of calcium that excreted into the urine.[6,7] The mean subjects age in our study was comparably higher compared with the average age of other comparative studies.

Our results show that the median attenuation rate of NCCTs radiolucent stone is 661 (200-1499) HU, whereas the median attenuation rate for radio-opaque stones is 941.6 (460-1499) HU. This finding is like the study conducted by Huang et al.[3] which also described the rate of attenuation of CT HU and its predictive value on whether a radio-opaque calculus (calcium predominant stone) or radiolucent (predominant stone of gout). They do a multivariate analysis of 84 ureteric stone detected by NCCT and found that HU level, and not stone size, was the most significant factors to predict whether urinary stone would be seen on KUB. They concluded that all urinary tract stones with a density of > 800 HU could be seen in the KUB, while 17 (74%) of 23 stones with a density of < 200 HU could not see in the KUB.[8]

Correlation of CT attenuation rates with stone composition has been widely studied in some of the latest literature. A study by Patel et al.[9] explained that stone that has HU level in the range of 879 ± 230 consisted mainly of calcium oxalate monohydrate, while stone with lower HU level (338 ± 145) usually consisted of uric acid stones.[8] Another study by Demirel et al. describes a similar range of HU for calcium oxalate stones (812 ± 135) and uric acid stones (413 ± 143) .[10] Our study findings along with these two other studies described previously, support the idea radio-opaque stones tend to have a higher calcium oxalate composition and radiolucent stones tend to composed by uric acid.

Cut-off value of HU which is determined with optimal sensitivity and specificity in predicting stone radio-lucency or radio-opacity expected to change the clinical management of urinary stone, which expected to decreased demand for KUB examination after NCCT, thus will prevent patients from unnecessary radiation exposure.

The cut-off ROC value of 500 HU which was used in our study had proven to have good predictability. Chua et al, concluded that ROC curve would produce the best cut value at 498.5 HU for identifying urinary tract stones. Urinary tract stones that had HU level below this threshold were more likely to be radio-lucent with a sensitivity of 71.4% and specificity 87.5%. On the other hand, urinary stones with HU above this threshold value is to predict to be radio-opaque stones with a sensitivity of 89.3% and specificity of 87.3%.[2] Significant statistical differences were noted ($p \leq 0.001$) on the sensitivity and specificity of HU value with a 500 cut-off.

Besides used to predict the composition of urinary stone, HU value was examined further by other studies, with stone size categorization either above 4 mm or below 4 mm, [10] to further determine the success rate of several urinary stones treatment modalities such as URS[11]; extracorporeal shock wave lithotripsy (ESWL)[12]; and PCNL. We suggest of further study examining the utility of HU values, not only for predicting

urinary stone composition but also for predicting success rate and complication rate of urinary stone treatment with a bigger study subject.

CONCLUSION

Based on the ROC curve, the threshold of 500 HU on the CT scan is determined as the optimal cutoff point in determining whether a urinary stone composition is predominantly calcium stone or uric acid stone. HU below 500 is suitable to be used to predict uric acid stones, and HU value above 500 was used to identified calcium stone with an overall sensitivity of 71.4%, specificity 87.5%, positive predictive value 83.3% and negative predictive value 77.8 %. Stone size but not stone location is the variable that affects sensitivity and specificity HU value.

REFERENCES

1. Curhan G, Goldfarb D, Trinchier A. 2008. Epidemiology of stone disease. In: Denstedt JD, Khoury S (eds) Stone disease.Health Publications, Paris, pp 9–20
2. Chua M.E, Gatchalian G.T, Corsino M.V, Reyes B.B. 2012. Diagnostic utility of attenuation measurement (Hounsfield units) in computed tomography stonogram in predicting the radioopacity of urinary calculi in plain abdominal radiographs. Int Urol Nephrol 2012; 44: 1349-55
3. Huang C.C, Chuang C.K, Wong Y.C, Wang L.J, Wu C.H. 2009. Useful prediction of ureteral calculi visibility on abdominal radiographs based on calculi characteristics on unenhanced helical CT and CT scout radiographs. Int J Clin Pract 2009; 63: 292-8
4. Spettel S, Shah P, Sekhar K, Herr A, White MD. 2013. Using Hounsfield unit measurement and urine parameters to predict uric acid stones. Urology 2013; 82: 22-6
5. Shirazi F, Shahpourian F, Khachian A, Hosseini F, Rad A, Heidari S, Sanjari M (2009) Personal characteristics and urinary stones. Hong Kong J Nephrol 11(1):14–19
6. Michaels EK, Nakagawa Y, Miura N et al (2004) Racial variation in gender frequency of calcium urolithiasis. J Urol 152:2228–2231
7. Nordin BE, Need AG, Morris HA, Horowitz M (2009) Biochemical variables in pre- and postmenopausal women: reconciling the calcium and estrogen hypotheses. Osteoporos Int 9:351–357
8. McKane WR, Khosla S, Burritt MF (2015) Mechanism of renal calcium conservation with estrogen replacement therapy in women in early postmenopause—a clinical research center study. J Clin Endocrinol Metab 80: 3458–3464
9. Patel SR, Haleblian G, Zabbo A, Pareek G (2009) Hounsfield units on computed tomography predict calcium stone subtype composition. Urol Int 83(2):175–180
10. Demirel A, Suma S (2013) The efficacy of non-contrast helical computed tomography in the prediction of urinary stone composition in vivo. J Int Med Res 31(1):1–5
11. Kim JW, Chae JY, Kim JW, Oh MM, Park HS, Moon du G, Yoon CY. Computed tomography-based novel prediction model for the stone-free rate of ureteroscopic lithotripsy. Urolithiasis 2014; 42: 75-79 [PMID: 24162952 DOI: 10.1007/s00240-013-0609-0]
12. Hameed DA, Elgammal MA, ElGanainy EO, Hageb A, Mohammed K, El-Taher AM, Mostafa MM, Ahmed AI. Comparing non contrast computerized tomography criteria versus dual X-ray absorptiometry as predictors of radioopaque upper urinary tract stone fragmentation after electromagnetic shockwave lithotripsy. Urolithiasis 2013; 41: 511-515.