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RESEARCH ARTICLE
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DIAGNOSTIC ACCURACY OF CT HOUNSFIELD UNIT FOR DETECTION OF CALCIUM STONES IN PATIENTS WITH RENAL STONE DISEASE

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Abstract

Objective

To assess diagnostic accuracy of CT Hounsfield for calcium stones in patients with renal stone disease taking stone chemical composition as gold standard.

Methodology

A descriptive, cross-sectional study was conducted at the Department of Urology, Allied Hospital, Faisalabad from 20 August 2019 to 19 February 2020. A total of 201 patients aged 15-60 years with kidney stones undergoing percutaneous nephrolithotomy were included in the study by non-probability consecutive sampling. Non-CT scan was performed using GE-128 slice and Hounsfield unit was determined. All patients underwent PCNL and extracted stones were sent for analysis.

Results

CT Hounsfield unit had a sensitivity of 93.14%, specificity of 91.92%, positive predictive value of 92.23% and a negative predictive value of 92.54%. There was no significant difference between overall accuracy between patients aged 15-40 years vs older patients i.e. 92.67% and 92.16%, respectively. An accuracy of 94.92% was recorded in males which was significantly higher than 89.16% in females. Highest accuracy was for stones in middle calyx i.e. 95.35% and lower calyx i.e. 92.63%.

Conclusion

Hounsfield unit has a high accuracy for diagnosis of calcium stones in patients with renal stones. It is also an efficient tool for differentiating different stone types by composition.

Keywords: Computed tomography, Kidney stones, Nephrolithiasis

Introduction

Nephrolithiasis, also known commonly as kidney stones are solid deposits of minerals and salts in the kidneys. They can also occur in ureters or bladder and can be composed of calcium, uric acid,

cystine or struvite. About 70% of the kidney stones are made of calcium oxalate.[1] They can cause severe pain, nausea, vomiting, blood in urine and painful urination. Diet and hydrationusually resolve the stones but sometimes medical intervention is needed to dissolve them.[2]

Contrast enhanced CT scan is usually performed to diagnose kidney stones and examine their composition. Percutaneous nephrolithotomy is performed for lower polar stones and shock wave lithotripsy is performed to resolve non-polar small-moderate stones. CT Hounsfield unit possesses great accuracy in detection of calcium containing renal stones.[3, 4]

It has been proved by a previous study that CT Hounsfield can differentiate stones by composition such as uric acid vs calcified stone and other minerals including struvite, uric acid, carbonate apatite and calcium oxalate stones with a high sensitivity and specificity of 80% and 84%, respectively ($p<0.001$).[5]Overall detection of calcium stones was 82% (112 out of 137).Calculus composition vs. HU is given respectively as uric acid (541.88±58.69), calcium oxalate monohydrate+ calcium oxalate dihydrate (960.44±244.84) calcium oxalate monohydrate COM (1016.82±243.63).

No such study has been conducted in our country in the past which can establish the diagnostic importance of CT Hounsfield in determining the renal stone composition of calcium content holding stones without stone analysis. So, a study targeting this evaluation will be highly useful for renal stone management in our patients, preventing unnecessary surgery and unnecessary use of ESWL in patients with renal stones.

The present study was conducted to assess diagnostic accuracy of CT Hounsfield for calcium stones in patients with renal stone disease taking stone chemical composition as gold standard.

Methodology

A descriptive, cross-sectional study was conducted at the Department of Urology, Allied Hospital, Faisalabad from 20 August 2019 to 19 February 2020. A total of 201 patients aged 15-60 years with kidney stones undergoing percutaneous nephrolithotomy were included in the study by non-probability consecutive sampling. The sample size was calculated by estimating 80% sensitivity, 84% specificity of PCNL, 80% incidence of stones, and 95% confidence interval. Pregnant women, children, those with BMI greater than 35 and patients with claustrophobia were excluded.

Research proposal was approved by the Ethical Review Committee and informed consent was taken from patients. Non-CT scan was performed using GE-128 slice and Hounsfield unit was determined. All patients underwent PCNL and extracted stones were sent for analysis.

All the data was entered and analyzed by using SPSS V-22. Mean and standard deviation were calculated for all quantitative variables like age and stone size. Frequency and percentage were calculated for all qualitative variables like gender and location. Sensitivity and specificity was calculated by constructing a 2x2 table. Likelihood ratio and ROC were also calculated. Effect modifiers like age, stonesize, gender and stone location were controlled by stratification. Post stratification diagnostic accuracy was calculated.

Results

A total of 201 patients with mean age of 33.7 years were analyzed (Table I). Majority of patients (58.7%) were males and 41.2% patients were female. The mean stone size was 28.5 mm with 94 (46.7%) stones sized 25 mm or less and 107 (53.7%) stones were larger than 25 mm. Most of the stones were located in the lower calyx (47.2%), followed by 31.3% in upper calyx.

All the patients were subjected to first computed tomography and then PCNL was done. CT supported the diagnosis of calcium stones in 103 patients. Chemical analysis confirmed calcium stones in 98 cases. Table II shows positives and negatives on CT and chemical composition stratified by patients' demographics. CT Hounsfield unit had a sensitivity of 93.14%, specificity of 91.92%, positive predictive value of 92.23% and a negative predictive value of 92.54%.

Table III shows the diagnostic accuracy of CT Hounsfield unit by patients' features. There was no significant difference between overall accuracy between patients aged 15-40 years vs older patients i.e.92.67% and 92.16%, respectively. An accuracy of 94.92% was recorded in males which was

significantly higher than 89.16% in females. Highest accuracy was for stones in middle calyx i.e. 95.35% and lower calyx i.e. 92.63%.

Table I: Baseline demographic and clinical features

Features	**N (%)**
Mean age	33.73 ± 10.61 years
15-40	150 (74.6%)
41-60	51 (25.3%)
Gender	
Male	118 (58.7%)
Female	83 (41.2%)
Mean stone size	28.52 ± 8.93 mm
≤ 25 mm	94 (46.7%)
>25 mm	107 (53.2%)
Location of stone	
Upper calyx	63 (31.3%)
Middle calyx	43 (21.3%)
Lower calyx	95 (47.2%)

Table II: Comparison of diagnostic results of CT Hounsfield Unitvs Chemical Compositionfor Detection of Calcium Stones

	Positive Result on Chemical Composition	**Negative Result on Chemical Composition**	**P value**
Positive on CT	95 (true positive)	08 (false positive)	0.0001
Negative on CT	07 (false negative)	91 (true negative)	
Age			
15-40 years (n=150)			
Positive on CT	74 (true positive)	07 (false positive)	0.0001
Negative on CT	04 (false negative)	65 (true negative)	
41-60 years (n=51)			
Positive on CT	21 (true positive)	01 (false positive)	0.0001
Negative on CT	03 (false negative)	26 (true negative)	
Gender			
Male (n=118)			
Positive on CT	61 (true positive)	03 (false negative)	0.0001
Negative on CT	03 (false negative)	51 (true negative)	
Female (n=83)			
Positive on CT	34 (true positive)	05 (false positive)	0.0001
Negative on CT	04 (false negative)	40 (true negative)	
Stone size			
≤25 mm (n=94)			
Positive on CT	36 (true positive)	05 (false positive)	0.0001
Negative on CT	03 (false negative)	50 (true negative)	
>25 mm (n=107)			
Positive on CT	59 (true positive)	03 (false positive)	0.0001
Negative on CT	04 (false negative)	41 (true negative)	
Stone location			
Upper calyx (n=63)			
Positive on CT	24 (true positive)	01 (false positive)	0.0001
Negative on CT	05 (false negative)	33 (true negative)	
Middle calyx (n=43)			
Positive on CT	24 (true positive)	01 (false positive)	0.0001
Negative on CT	01 (false negative)	17 (true negative)	
Lower calyx (n=95)			
Positive on CT	47 (true positive)	06 (false positive)	0.0001
Negative on CT	01 (false negative)	41 (true negative)	

Table III: Diagnostic Accuracy of CT Hounsfield Unit

	Sensitivity	Specificity	Positive predictive value	Negative predictive value	Diagnostic accuracy
Age					
15-40	94.87%	90.28%	91.36%	94.20%	92.67%
41-60	87.50%	92.30%	95.45%	89.66%	92.16%
Gender					
Male	95.31%	94.44%	95.31%	94.44%	94.92%
Female	89.47%	88.89%	87.18%	90.91%	89.16%
Mean stone size					
≤ 25 mm	92.31%	90.91%	87.80%	94.34%	91.49%
>25 mm	93.65%	93.18%	95.16%	91.11%	93.46%
Location of stone					
Upper calyx	82.76%	97.06%	96.0%	86.84%	90.48%
Middle calyx	96.0%	94.44%	96.0%	94.44%	95.35%
Lower calyx	97.92%	87.23%	88.68%	97.62%	92.63%

Discussion

This study was conduced to assess the diagnostic accuracy of CT Hounsfield unit for calcium kidney stones in comparison with chemical composition. CT Hounsfield unit had a sensitivity of 93.14%, specificity of 91.92%, positive predictive value of 92.23%, negative predictive value of 92.54% and an overall diagnostic accuracy was 92.54%. A previous study evaluating its accuracy for differentiation between uric acid from calcium, calcium oxalate, struvite and carbonate apatite stones.[6] The results showed significant findings between all stones types with a 1.66 cut-off value, 84% specificity and 80% sensitivity. Similar results were shown in previous studies.[7, 8]

Another study conducted in Asia reported a high accuracy of HU values for identifying calcium stones including dihydrate, calcium oxalate and monohydrate apart from other stone types.[9] However, the values were similar for uric acid and cystine stones so it may not be very efficient to differentiate these stones. Calcium phosphate stones had the highest density and HU values which is similar to our study.

A local study by Shaukat et al showed that a Hounsfield unit of less than 934 had a sensitivity of 94.92%, specificity of 81.40%, positive predictive value of 95.90% and negative predictive valve of 77.78%.[10] The overall accuracy was 92.50% similar to our study. Barsoum et al reported a cut off value of 6.2, a sensitivity and specificity of 92.3% and 93.3%, respectively which was statistically significant with a p value of 0.0001.[11]

Lu et al analyzed patients with pyonephrosis and hydronephrosis and use of HU units for distinguishing them. The best cut-off value was 9.5 with a specificity of 70.2% sensitivity of 71.4%.[12] In another study struvite stones could be predicted by 85% accuracy when the HU was greater than 600 and a sensitivity of 87% when the HU was 500 or less.[13]

Conclusion

Hounsfield unit has a high accuracy for diagnosis of calcium stones in patients with renal stones. It is also an efficient tool for differentiating different stone types by composition.

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