Role of Computerized Tomography in the Diagnosis of Calcium Oxalate Calculi

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Abstract

Background: CT can be used to determine the composition of a stone. Using Hounsfield Units (HU), a CT scan of the abdomen and pelvis may be utilized to diagnose and evaluate renal stones (all types).

Objective: To determine the role of CT in the diagnosis of Calcium oxalate renal calculi on the basis of Hounsfield unit, taking chemical analysis as the gold standard.

Methodology: Study Design: Cross-sectional study. Settings: Department of Radiology, Allied Hospital, Faisalabad. Study duration: 1st July 2020 to 31st December 2020. Sampling: Non-probability consecutive sampling technique. A sum of 200 patients with urinary stones of both genders (Male and Female) with age 15-55 years were incorporated. Hounsfield units were calculated for each stone using in-built software in the CT scan machine. The presence of CT attenuation density of >1200 HU was taken as calcium oxalate stone and ≤1200 HU was taken as non-calcium oxalate stones. Stones of all patients after surgery were shipped off to the pathology research facility for compound investigation.

Results: In CT positive cases, 95 were true positive and 08 were false positive. While in CT negative patients, 90 were true negative and 07 were false negative. Overall sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of CT in separating diverse renal calculi based on the Hounsfield unit, accepting compound investigation as the gold standard was 93.13%, 91.83%, 92.23%, 92.78%, and 92.5% respectively.

Conclusion: This study concluded that the diagnostic accuracy of CT Hounsfield units for the detection of calcium oxalate stones is very high.

Keywords: Urolithiasis, Calcium oxalate, Computed tomography, Hounsfield units

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Introduction

Urolithiasis is a common illness around the world and upsets a wide array of the patient populace, paying little heed to race, culture, or geographic cutoff points.[1] In the previous few decades, there has been a developing event of urinary stone illness both in cutting edge and advancing countries because of varieties in way of life, for the most part, because of the expanding incidence of obesity.[1] Recent study has also verified a shifting composition of urolithiasis as well as a substantial surge in the incidence of stone disease in women and younger patients over the last decade.[2] Because of the link between urolithiasis and complications like infection and chronic renal disease, as well as the increased risk of recurrence, proper urolithiasis care has substantial clinical implications.[3]

The exact reason for urinary stones is not known but the most regularly perceived hypothesis is the supersaturation, crystallization theory.[5] According to this idea, as the grouping of solutes in the urine rises, the solubility product is reached above which disintegrated solutes can form nuclei of its solid phase(the metastable zone). These nuclei can be homogeneous or heterogeneous. Homogeneous nucleation occurs in unadulterated arrangements and needs more thermodynamic energy. Heterogeneous nucleation is known to initiate crystal formation.[5] Conformation of renal system stone is imperative for defining the best method of treatment to decrease the risk of recurrence.[6] For instance calculi made of cysteine or calcium oxalate monohydrate have a firm structure and can be managed efficiently with percutaneous nephrolithotomy.[6]

Diverse radiological investigations are used to gauge renal stones and among all, non-contrast-enhanced computerized tomography (CT) delivers the highest level of diagnostic accuracy with small radiation contact for urinary stones.[7] Stone configuration can be explicitly assessed using CT.[8,9] CT scan can be used for judgment and assessment of renal calculi with the help of Hounsfield Units (HU) and it is known that it has high sensitivity.[10] In a study, the sensitivity, and specificity in distinguishing a calcium oxalate from non-calcium oxalate calculus

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were 97.8% and 92.3%, respectively.[10]

Urological treatment of urinary tract calculi trusts on several diverse factors such as stone dimensions, site, quantity, anatomy, and chemical structure. Precise pre-treatment identification of urinary stone structure is indispensable and considerably impacts proper management.[11] Normally there is no radiological investigation available for measuring the stone composition pre-operatively (to check the size and position of the stone), so the main goal of my study was to appraise the diagnostic accuracy of CT in the diagnosis of calcium oxalate renal calculi on the basis of Hounsfield units, taking chemical analysis as a gold standard. The obtainable literature in this part is very rare. The outcomes of my study may be a useful addition to the existing literature and may aid in understanding calcium oxalate stone knowing its specific radiologic features permits the radiologist to play a crucial role in notifying the clinician to use proper treatment options.

Methodology

This was a cross-sectional study conducted at the Department of Radiology, Allied Hospital, Faisalabad, from 1st July 2020 to 31st December 2020. Non-probability consecutive sampling technique was used. A total of 200 cases of both gender and between 15 and 55 years of age were included after informed consent. Ethical approval was sought from the Ethical Committee of the Hospital. These patients were diagnosed clinically and radiologically as having renal calculi. Non-contrast CT KUB was used to determine the size, location, and composition of stones. Hounsfield unit density was calculated for each stone by dividing the Hounsfield unit by the greatest diameter where the greatest diameter is measured in both coronal and axial planes with (MIP) view.128 slice GE whole-body CT scanner was used at voltage 120V, current 200mA, pitch 0.9:1, collimation 40mm and helical thickness 5 mm. The presence of CT attenuation density of >1200 HU was taken as calcium oxalate stone and ≤1200 HU was taken as non-calcium oxalate stones. All stones after surgery were sent to the pathology department to detect the presence of calcium and oxalate on chemical analysis using infrared spectroscopy. Patients with Chronic diseases i.e. chronic renal failure, chronic liver disease, hypothyroidism, hyperthyroidism, and patients with a history of any chronic drug usage (assessed on history and medical record) were excluded. Overall sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of CT were calculated. These values were calculated for renal and ureteric stones as well. Data were analyzed by using SPSS version 20.

Results

Age assortment in this study was from 15-55 years, with a mean age of 33.74±10.64 years. The majority of the patients 141 (70.5%) were between 15 to 35 years of age as shown in Table-I. Out of these 200 patients, females were 117 (58.5%) and males were 83 (41.5%) with a female to male ratio of 1.4:1 (Table-I). The mean duration of disease was 7.51±2.58 months. The mean size of the stone was 28.59±8.90 mm.

CT reinforced the diagnosis of calcium oxalate stones in 103 patients. Chemical analysis established calcium oxalate stones in 102 cases. In CT positive cases, true positive were 95 and false-positive were eight. While in CT negative patients, the true negative were 90 and the false negative were seven. (Table-II) Overall sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of CT in differentiating calcium oxalate renal calculi on the basis of the Hounsfield unit, taking chemical analysis as the gold standard was 93.13%, 91.83%, 92.23%, 92.78%, and 92.50% respectively.

The diagnostic accuracy of CT in diagnosing ureteric calculi was more than that of kidney stones. (Table III & IV)

Table-I: Distribution according to Age of patients (n=200).

Age (years)	No. of Patients	Percentage
15-35	141	70.50
36-55	59	29.50
Total	200	100.0

Table-II: Diagnostic accuracy of CT in diagnosing calcium oxalate renal calculi on the basis of Hounsfield unit, taking chemical analysis as a gold standard.

	Positive result on chemical composition	Negative result on chemical composition	P-value
Positive on CT	95 (TP)*	08 (FP)***	0.0001
Negative on CT	07 (FN)**	90 (TN)****	

*-TP=True positive **-FP=False positive ***-FN=False negative ****-TN=True negative
Sensitivity: 93.13%; Specificity: 91.83%
Positive Predictive Value (PPV): 92.23%; Negative Predictive Value (NPV): 92.78%
Diagnostic Accuracy: 92.5%

Table-III: Diagnostic accuracy with respect to kidney stones (n=129).

	Positive result on chemical composition	Negative result on chemical composition	P-value
Positive on CT	61 (TP)	06 (FP)	
Negative on CT	06 (FN)	56 (TN)	0.0001

Sensitivity: 91.04%; Specificity: 90.32%
Positive Predictive Value (PPV): 91.04%; Negative Predictive Value (NPV): 90.32%
Diagnostic Accuracy: 90.7%

Table-IV: Diagnostic accuracy with respect to ureteric stone (n=71).

	Positive result on chemical composition	Negative result on chemical composition	P-value
Positive on CT	34 (TP)	02 (FP)	
Negative on CT	01 (FN)	34 (TN)	0.0001

Sensitivity: 97.14%: Specificity: 94.44%
Positive Predictive Value (PPV): 94.44%: Negative Predictive Value (NPV): 97.14%
Diagnostic Accuracy: 95.77%

Discussion

In order to diagnose renal stones, clinicians and students need to be familiar with a growing array of imaging tools, imaging conventions, and research Centre information. Clinicians should be able to interpret e images with precise outcomes in order to provide proper care. Improving the ease of translation will almost certainly cut down on the time it takes to learn how to read a CT scan. Due to its great sensitivity and specificity, processed tomography (CT) is frequently used to distinguish renal stones.[10,11] To measure stone design and guide stone treatment, Hounsfield Unit (HU) estimates of stones examined with single-energy CT (SECT) have traditionally been used. Nonetheless, the Hounsfield Unit evaluation of SECT-imaged calculi is out of whack, with unpredictable results.

This study was done to determine the diagnostic accuracy of CT in discriminating calcium oxalate renal calculi using the Hounsfield unit taking chemical analysis as the gold standard. In 103 cases, CT confirmed the diagnosis of calcium oxalate stones. In 102 cases, chemical analysis revealed calcium oxalate stones. True positives were 95 percent and false positives were 8 in CT-positive patients. Real negatives were 90 and false negatives were 7. In CT negative patients, true negatives were 90 and false negatives were 7. On the basis of the house field unit, the sensitivity, specificity, PPV, NPV, and diagnostic accuracy of CT in diagnosing calcium oxalate renal calculi were 93.13%, 91.83%, 92.23%, 92.78%, and 92.5%, respectively. Bellin et al[10] described that attenuation and density of stones determined by Computerized Tomography can be used to envisage calculus configuration with 63%-80% accurateness. Uric acid, cysteine, calcium oxalate monohydrate, and brushite calculi have been recognized in vitro with an accuracy surpassing 84% on the basis of attenuation dimensions.[11-14] Even though the attenuation values of stones (particularly struvite stones) fluctuate among studies, CT is precise in serving forecast stone configuration in vitro. Patel et al[12] explored that Hounsfield units could segregate subtypes of calcium stones, and stated them to be useful for identifying calcium oxalate monohydrate and dihydrate stones. In a comparable study, the researchers conveyed that calcium stones could be recognized with high precision using HU values, but that there was an intersection between the HU values of cysteine and uric acid stones, causing it hard to separate these kinds of stones.[13] Grounded on their HU units, the calcium phosphate calculi (brushite and apatite) are calculi with the maximum density as established in our study (1123±254 and 844±346). Saw et al[15] scanned 127 urinary calculi at 1 mm, 3 mm, and 10 mm collimation. At 1 mm collimation, the spiral CT scan differentiated all stone types except brushite from hydroxyapatite (to know the exact position of stone). Nakada et al[16] evaluated NCHCT in determining stone setup in vivo. They set up a significant change in the Hounsfield estimation of uric acid and calcium oxalate calculi. Motley et al[17] did a study on 98 patients and showed that 85 patients had calcium stones, 7 UA stones, 4 struvite stones, and 2 cysteine stones. Their Hounsfield units were 440±262, 270±134, 401±198, and 248±0 correspondingly. They did not find a momentous alteration among average Hounsfield Units for these types of stones. Demirel et al[18] in 85 patients, revealed that 52 patients had calcium oxalate stones, 19 struvite stones, and 14 UA stones, whose

Hounsfield units were 812±135, 614±121, and 413±143, correspondingly. It was feasible to separate among three kinds of calculi based on their normal Hounsfield units.

Conclusion

The diagnostic accuracy of CT in identifying distinct renal stones on the basis of the Hounsfield unit was found to be quite high in this investigation. As a result, we believe that the CT Hounsfield unit should be used routinely in general practice to diagnose calcium oxalate calculi prior to surgery, allowing clinicians to implement appropriate care strategies.

Authors Contribution: NN: Design of work, Acquisition and analysis of data and Drafting. **ABS:** Conception of work Interpretation of data and revising. **NS:** Conception of work, Interpretation of data and drafting. **TN:** Acquisition, Analysis of data and revising. **SAM:** Design of work and drafting. **d0:** Interptation of data and revising.
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