

Role of Computed Tomography in Differentiation of Radio-Lucent Stones from Radio-Opaque Stones in The Renal System Depending on Attenuation Measurements (Hounsfield Unit)

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ABSTRACT

Renal calculus remains to be a common problem in the hospital. It is the third most common urological problem after urinary tract infection and prostate disease

Computed tomography (CT) has a superior sensitivity and specificity over all other modalities in

Diagnosis of renal stones in determining the size and number of kidney stones, no matter how small it is, also it helps in the identification of Hounsfield unit (HU) and thus determines the composition of gravel.

Aim:

The aim of this study is to differentiate between radio-opaque from radio lucent stones depending on attenuation measurements of the Hounsfield unit (HU) and to find the cutoff value depending on the Hounsfield unit in computed tomography (CT).

PATIENT AND METHOD:

This was a cross-sectional study of 100 patients (65 male and 35 female) aged between 18 and 80, having kidney stones of size more than or equal (10 mm). The study was done between September 2014 and June 2015 in Al-Emammain Al-Kadhymain Medical City, Baghdad, Iraq. In all patients, an X-ray of the Kidney, ureter, and bladder (KUB) was done after preparation, and then non contrast Computed Tomography (CT) was performed to all patients. Two parameters were studied, which are the appearance of stone on KUB and Hounsfield unit for each stone was measured in Computed Tomography (CT).

RESULTS:

We classified the stones according to their appearance on KUB to Radio-Opaque stone (71 stones) and Radio-Lucent stone (29 stones).

By statistical analysis, we found that the cut-off value of HU was 573, with a sensitivity of 97.2% and specificity of 93.1%.

CONCLUSION

Find the cut-off value of the Hounsfield unit (HU), which is a value in the classification of gravel according to their appearance.

KEYWORDS: Radio-Opaque stone, Radio-Lucent stone, Hounsfield unit.

INTRODUCTION

Kidney stones (renal calculi) are solid masses made of crystals. Kidney stones originate in the kidneys but can be found at any point in the urinary tract. The urinary tract includes the kidneys, ureters, bladder, and urethra [1,2].

Renal calculus remains to be a common presentation in the hospital. It is the third most common urological problem after urinary tract infection, with a lifetime prevalence of Urolithiasis at 10-15%. The prevalence has risen over 20 years from the mid-1970s to the mid-1990s. The diagnosis of urolithiasis is largely dependent on analysing the clinical presentation and physical examination. Suspicion is confirmed with radiologic tests [3,4,5], particularly the non-contrast-enhanced computed tomography (CT) scan. The advent of non-enhanced CT has not only provided detection and confirmation of calculi but also accurate detection of its size and location. Non-contrast helical CT scan provides several advantages over the KUB radiograph such as detection of radiolucent calculi, sensitivity for small stones, identification of other causes of flank pain as well as avoidance of any preparation prior to the procedure. However, a KUB radiograph has remained part of the protocol for most clinicians even after a non-contrast helical CT scan is carried out because of its impact in clinical decision-making prior to treatment. Due to the higher radiation dose with CT, conventional or digital radiography is being used to monitor the passage of stones if radiographic follow-up is believed to be indicated [6,7,8]

Nephrolithiasis occurs in all parts of the world. The lifetime prevalence of nephrolithiasis is approximately 12% for men and 7% for women in the United States, and it is rising. Having a family member with a history of stones doubles these rates. Approximately 30 million people are at risk in the United States. Roughly 2 million patients present on an outpatient basis with stone disease each year in the United States, which is a 40% increase from 1994 [9]. The incidence of urinary tract stone disease in developed countries is similar to that in the United States; the annual incidence of urinary tract stones in the industrialized world is estimated to be 0.2%. Stone disease is rare in only a few areas.

Most urinary calculi develop in persons aged 20-49 years. Peak incidence occurs in people aged 35-45 years, but the disease can affect anyone at any age. An initial stone attack after the age of 50 years is relatively uncommon. Nephrolithiasis in children is rare. [10]

Urolithiasis is more common in males (male-to-female ratio of 3:1). Stones due to infection are more common in women than in men.

Approximately 80-85% of stones pass spontaneously. Approximately 20% of patients require hospital admission because of unrelenting pain, proximal UTI, or inability to pass the stone [11,12]

A study done in Iraq showed that Epidemiology and pathogenesis in urinary stones predominantly of mixed type: calcium oxalate was the commonest compound. Anatomical distribution of urinary stones shows that renal stones are more common than Urolithiasis and bladder stones.

STUDY DESIGN AND PERIOD
The study was a cross-sectional analytic study extended from September 2014 to June 2015

STUDY SAMPLE
The study was conducted in the department of diagnostic radiology in Al-Emammain Al-Kadhymain Medical City, Baghdad, Iraq. One hundred patients (65 males and 35 females) All the patients included in this study are sent from the urology department, and they have renal stones equal to or more than 10mm in diameter as shown by the U/S examination.

Exclusion criteria

1. Patient age (less than 18 and more than 80 years).
2. Stone size (more than or equal to 10 mm).
3. pregnancy
4. Patient with Barium contrast study within three days before the examination.

DATA COLLECTION

Full clinical history was taken from all patients included in this study. All the patients were submitted to the plain X-ray of the abdomen (KUB) and non-enhanced CT of the abdomen.

Plain X-Ray of the abdomen (KUB-(kidney, ureters, bladder))

KUB was performed to all patients after preparation, which is:

1. Before one day from examination, the patient was asked to take an early dinner and 1-2 spoons of castor oil to avoid gasses shadow in the KUB X-ray.
2. The examination is performed in a supine position, and ask the patient to take a deep breath. The X-ray field extends from the pubic Asymptotic to the superior aspect of the kidney. The exposure factor was-(80-100 kv, 60MAs), and this exposure factor according to the patient built.

The following parameters were studied by KUB examination:

1. Size of stone.
 2. Appearance of stone (radio-lucent or radio-opaque).
- The study focused on the renal stone that measures 10 mm or more.

Computed Tomography (CT)

The examination was performed in a CT unit with Som atom definition AS 64 slice Siemens medical system Germany. A non-enhanced scan was performed to all

I.	IV.	VII.	X. ASYMPTOTIC 95% CONFIDENCE INTERVAL	
II.	V.	VIII.		
III. ARE A	VI. SID. ERROR	IX. ASYMPTOTIC SIG. 6	XI. LOWER BOUND	XII. UPPER BOUND

patients. The imaging protocol included a section thickness of 1 mm for a detector configuration of 2 mm ^ 1 mm, rotation time 0.75s, pitch 1.172 table freedom per rotation, tube voltage 120 kV, and effective tube current time product 0.45 mA. The mean SD CT dose index was + 15.1 mGy. The images were viewed in axial sections

XIII. .948	XIV. 026	XV. . 000	XVI. . 587	XVII. 1.00 0
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; coronal reconstructions were created in multiplane reconstruction applications. Both KUB radiographs and non-contrast helical CT scan images were viewed by two independent radiology 'During the examination, we asked the patient to hold their breath and remain static

Attenuation values in HU were systematically measured with an elliptic region of interest (ROI) in the area of the stone. Stone size (length and width) was measured using the standard metric software devices provided in the workstation

The following parameters were studied by CT :

1. Size of stone.
2. Side of stone.
3. Number of stone
4. Hounsfield unit was measured

Statistical analysis

Statistical analysis was carried out using the Statistical Package for Social Sciences (SPSS for Windows version (I7.0). Demographic data of the cases included in the study were collated and graphed. Confidence intervals with the receiver

Operating characteristic (ROC) curve was constructed to

	Radio-opaque	Radio-
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 determine the best cut-off value for determining what Hounsfield value at which a calculus can be classified as a Radio-opaque or Radio-Lucent by CT Chi-square was used to test for the existence of a relationship between the stone appearance in radiology and gender.

Finally, the sensitivity, specificity, positive predictive value,

Negative predictive values › were obtained. All data analyses were conducted at a 0.05 significance level or at a 95% confidence interval.

RESULTS

		Gender		stones	lucent stones
		ma	fem		
		Mean	914.87		461.21
		Median	890.00		445.00
		Variance	43135.712		19558.670
Type of stone	Radio-Opaque No	Std. Deviation	207.691		139.852
		Minimum	397		307
	Radio-Lucent No	Maximum	1407		930
		Range	1010		623
Total No		65	35	100	

Table (1) descriptive statistics for Radio-Opaque Radiolucent Hounsfield (HU) stones

Figure 1- receiver operating characteristic curve to determine Hounsfield unit (HU) 573 as the best HU cut-off value for identifying radio-opaque stones from radio-lucent stones on computed tomography

Table 2- test results variables

Fig 2-Distribution data of Radio-Opaque and radio Lucent stones

Table (3) Observed values And Expected values of Radio-Opaque and Radiolucent according to their gender.

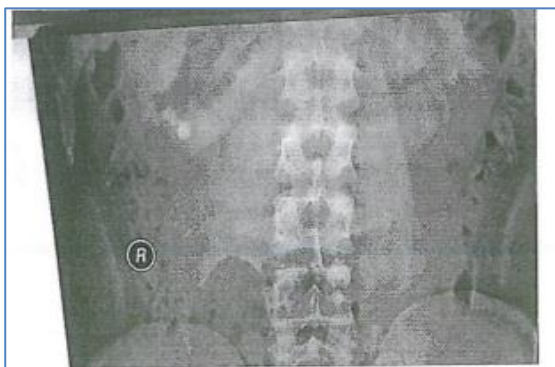
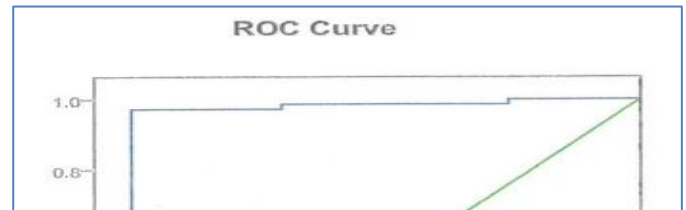


Figure 8-a)

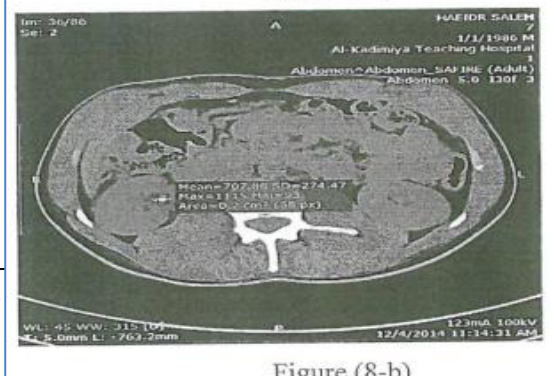
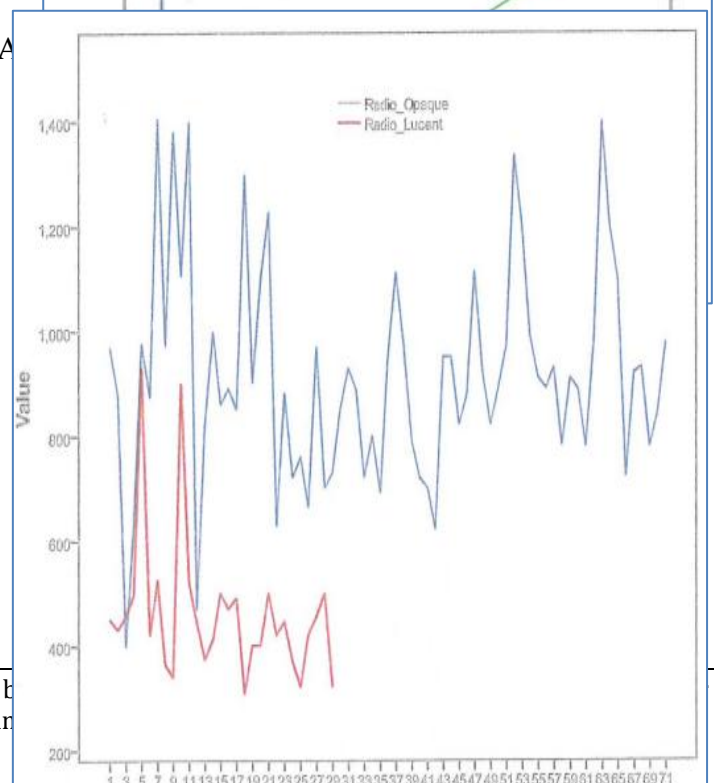
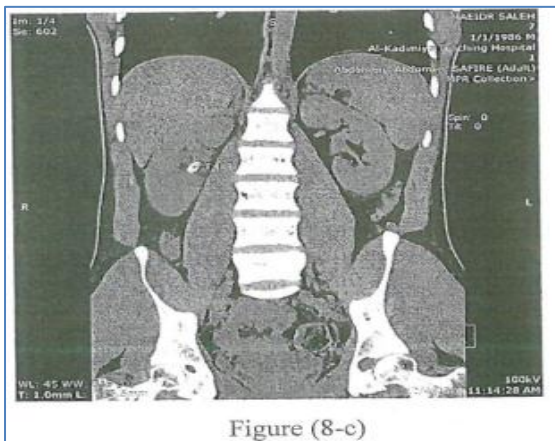


Figure (8-b)

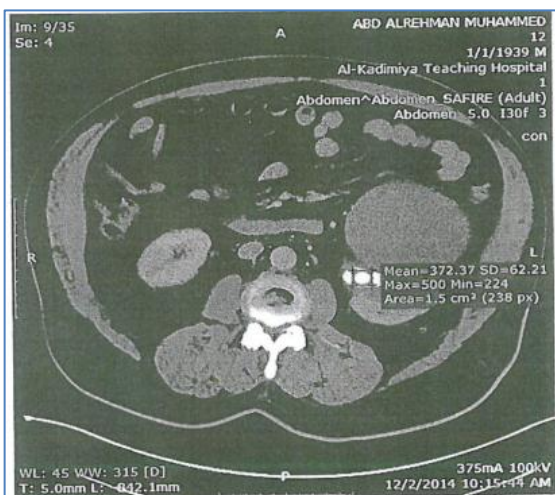
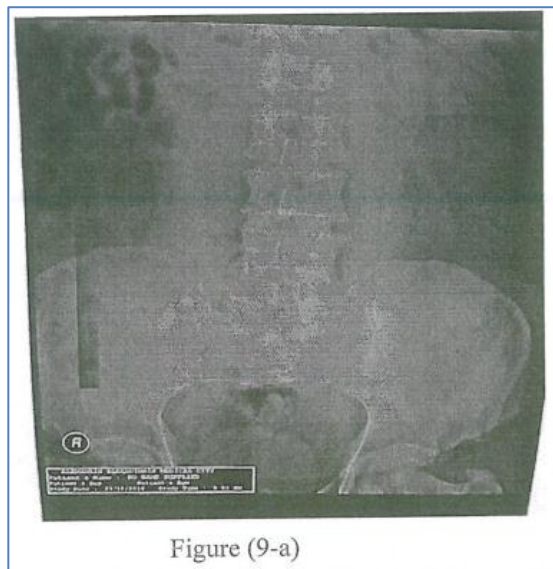
29-year-old male presented with right-side lion pain. Figures



(8-a) represent the plain x-ray with right site radio-opaque renal stone, and Figures (8-b) and Figure (8-c) represent axial and coronal CT with right site renal stone and its ITU measurements, respectively.



Seventy-six-year-old male presented with left-side lion pain. Figure (9-a) represents the plain x-ray with left site radio lucent renal stone, and figure (9-b) represents axial CT of left site renal stone with its HU measurement.



Discussion

CT is one of the best methods to detect kidney stones. All stones can be detected on CT except very rare stones composed of certain drug residuals (e.g., acyclovir). In recent years, the use of helical non-contrast computed tomography (CT) in patients with urinary system stones has increased. Hounsfield units (HU), a parameter generated from standard CT, are related to the density of the stone or structure of interest. HU can also be used to assess the CT density of urinary system stones. It has become an important diagnostic tool, not only for predicting the type of stone but also for determining the appropriate mode of treatment [13,14].

In our study, we try to determine the best cut-off value of the Hounsfield unit in order to differentiate between Radio-Opaque and Radio-Lucent stones to help the urologist to determine the type of treatment, either surgical or medical. [15]

In our study, we have 100 stones in 100 patients (65 male, 35 female) dealt with sizes more than or equal to 10mm. We find 71 radio-opaque with a mean value of HU 914.87 and Std. Deviation 207.69, 29 with mean value of HU 461.21 and Std. Deviation 207.96, 29 Tauro Deviation 139.85. by using the Receiver Operating Characteristic curve (ROC), we determined the best HU cut-off value is 573 with sensitivity 97.2% and specificity 93.1%

Previous studies done by researchers, such as the study of Chau (2012) [16,17], focused on size gravel 8.4mm with sample size 184 (121 radio-opaque with a mean value of HU 816.51 and Std. Deviation is 274.63 radio lucent with a mean value of HU 358.25 and Std. Deviation 156, whereas the best HU cut-off value was 498.5 with a sensitivity of 89.3% and specificity of 87.3% -Study of Chau (2014) focused on size gravel 7mm with sample size 203 (126 male, 77 female. The best HU cut-off value was 610, with a sensitivity of 82.9% and a specificity of 93.9%.

Study of Sfoungaristos (2014) [18] focused on size gravel 9.7mm with sample size 375 (206 radio-opaque, 169 radio-lucent, the best HU cut off value was 772.

Differences in results may be due to differences in the size of the gravel in the studies or because of the different environment or, the differing nature of the diet, or other factors which led to the different components of gravel [19,20].

We discussed the effect of gender on the appearance of gravel; in this aspect, the study agreed with a number of studies by Liapis and David, such as that showed that most of Radio-opaque stones are found in males while most of Radio-lucent stones are found in females.

Conclusion

1. Based on the constructed ROC curve, a threshold value of 573 in CT was established as a cut-off value in determining whether a calculus is a Radio-Opaque or Radio-Lucent.
2. Most of the Radio-Opaque stones were found in males, while of most of the Radio-Lucent stones were found in females.

References

1. Huang CC, Chuang CK, Wong YC, Wang LJ, Wu CH. 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;63:292–298. [[PubMed](#)] [[Google Scholar](#)]
2. Miller NL, Lingeman JE. Management of kidney stones. *BMJ.* 2007;334:468–472. [[PMC free article](#)] [[PubMed](#)] [[Google Scholar](#)]
3. Türk C, Knoll T, Petrik A, Sarica K, Skolarikos A, Straub M, Seitz C Guidelines on urolithiasis: European Association of Urology Guidelines, 2014 [[Google Scholar](#)]
4. Gupta NP, Ansari MS, Kesarvani P, Kapoor A, Mukhopadhyay S. Role of computed tomography with no contrast medium enhancement in predicting the outcome of extracorporeal shock wave lithotripsy for urinary calculi. *BJU Int.* 2005;95:1285-1288. [[PubMed](#)] [[Google Scholar](#)]
5. Pareek G, Hedican SP, Lee FT, Nakada SY. Shock wave lithotripsy success determined by skin-to-stone distance on computed tomography. *Urology.* 2005;66:941–944. [[PubMed](#)] [[Google Scholar](#)]
6. 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 radio-opaque upper urinary tract stone fragmentation after electromagnetic shockwave lithotripsy. *Urolithiasis.* 2013;41:511–515. [[PubMed](#)] [[Google Scholar](#)]
7. el-Assmy A, Abou-el-Ghar ME, el-Nahas AR, Refaie HF, Sheir KZ. Multidetector computed tomography: role in the determination of urinary stones composition and disintegration with extracorporeal shock wave lithotripsy--an in vitro study. *Urology.* 2011;77:286–290. [[PubMed](#)] [[Google Scholar](#)]
8. El-Assmy A, El-Nahas AR, Abou-El-Ghar ME, Awad BA, Sheir KZ. Kidney stone size and Hounsfield units predict successful shockwave lithotripsy in children. *Urology.* 2013;81:880–884. [[PubMed](#)] [[Google Scholar](#)]
9. Pearle, M.S., Calhoun, E.A., Curhan, G.C., and Urologic Diseases of America Project, 2005. Urologic diseases in America project: urolithiasis. *The Journal of Urology*, 173 (3), pp.848-857.
10. Ouzaid I, Al-Ohtani S, Dominique S, Hupertan V, Fernandez P, Hermieu JF, Delmas V, Ravery V. A 970 Hounsfield units (HU) threshold of kidney stone density on non-contrast computed tomography (NCCT) improves patients' selection for extracorporeal shockwave lithotripsy (ESWL): evidence from a prospective study. *BJU Int.* 2012;110:E438–E442. [[PubMed](#)] [[Google Scholar](#)]
11. Gücük A, Kemahlı E, Üyetürk U, Tuygun C, Yıldız M, Metin A. Routine flexible nephroscopy for percutaneous nephrolithotomy for renal stones with low density: a prospective, randomized study. *J Urol.* 2013;190:144–148. [[PubMed](#)] [[Google Scholar](#)]
12. 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. [[PubMed](#)] [[Google Scholar](#)]
13. Preminger GM, Tiselius HG, Assimos DG, Alken P, Buck AC, Gallucci M, Knoll T, Lingeman JE, Nakada SY, Pearle MS, et al. 2007 Guideline for the management of ureteral calculi. *Eur Urol.* 2007;52:1610–1631. [[PubMed](#)] [[Google Scholar](#)]

14. Erturhan S, Bayrak O, Mete A, Seckiner I, Urgun G, Sarica K. Can the Hounsfield unit predict the success of medically expulsive therapy? *Can Urol Assoc J.* 2013;7:E677–E680. [PMC free article] [PubMed] [Google Scholar]
15. Scales CD, Jr, et al. Urinary stone disease: advancing knowledge, patient care, and population health. *Clin J Am Soc Nephrol.* 2016;11:1305–1312. [PMC free article] [PubMed] [Google Scholar]
16. Chua ME, Gomez OR. Sapno LD. Lim SL. Morales ML Jr. 2014, Use of computed tomography scout film and Honsfield unit of computed tomography scan in predicting the radio-opacity of urinary calculi in plain kidney, ureter, and bladder
17. Smith-Bindman R, et al. Ultrasonography versus computed tomography for suspected nephrolithiasis. *N Engl J Med.* 2014;371:1100–1110. [PubMed] [Google Scholar]
18. Sfoungaristos, S., Kavouras, A., Kanatas, P., Duvdevani, M. and Perimenis, P., 2014. Early hospital admission and treatment onset may positively affect the spontaneous passage of ureteral stones in patients with renal colic. *Urology*, 84 (1), pp.16-21.
19. Coursey CA, et al. ACR Appropriateness Criteria (R) acute onset flank pain-suspicion of stone disease. *Ultrasound Q.* 2012;28:227–233. [PubMed] [Google Scholar]
20. Memarsadeghi M, et al. Unenhanced multi-detector row CT in patients suspected of having urinary stone disease: effect of section width on diagnosis. *Radiology.* 2005;235:530–536. [PubMed] [Google Scholar]