ISSN: 2581 – 3633
PubMed - National Library of Medicine - ID: 101745081

International Journal of Medical Science and Advanced Clinical Research (IJMACR)
Available Online at:www.ijmacr.com
Volume – 6, Issue – 2, April - 2023, Page No. : 143 - 148

Dual Energy Computed Tomography for Determination of Renal Calculi Composition: In-Vivo Analysis and In-Vitro Comparison with Qualitative Chemical Analysis

[1]Dr. Ashish Chandra, Postgraduate, Radiology Department, SDM College of Medical Sciences & Hospital
[2]Dr Rajeev Dibbad, Professor and Head, Radiology Department, SDM College of Medical Sciences & Hospital
[3]Dr Amrit Raj, Post graduate student, Department of Radio-diagnosis, SDM College of Medical Sciences & Hospital
[4]Dr Divya C, Post graduate student, Department of Radio-diagnosis, SDM College of Medical Sciences & Hospital
[5]Dr Anup L, Post graduate student, Department of Radio-diagnosis, SDM College of Medical Sciences & Hospital
[6]Dr Taha Ismail, Post graduate student, Department of Radio-diagnosis, SDM College of Medical Sciences & Hospital

Corresponding Author: Dr. Ashish Chandra, Postgraduate, Radiology Department, SDM College of Medical Sciences & Hospital

How to citation this article: Dr. Ashish Chandra, Dr Rajeev Dibbad, Dr Amrit Raj, Dr Divya C, Dr Anup L, Dr Taha Ismail, "Dual Energy Computed Tomography for Determination of Renal Calculi Composition: In-Vivo Analysis and In-Vitro Comparison With Qualitative Chemical Analysis", IJMACR- April - 2023, Volume – 6, Issue - 2, P. No. 143 – 148.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Dual energy CT (DECT) has the ability to differentiate the composition of the various renal calculi. An early diagnosis and treatment can therefore significantly alter the outcome of the disease. Objectives of the study were, Using dual-energy CT for establishing and characterization of renal calculi in patients clinically presenting with features and comparing the results postoperatively with biochemical qualitative analysis.

The study was conducted in the Department of Radiology, SDMCMSH, Dharwad using128 slice single source dual energy CT scanner. Forty patients were selected for the study. After the clinical examination of the patients with a written and informed consent, they were subjected to Dual energy-CT evaluation of KUB. The images were processed choosing a dual energy protocol.

Out of the 40 patients in our study who were clinically suspected cases/known cases of renal calculi, calcium oxalate were seen in 20 cases compromising 50% of total cases. Next common type was uric acid stone. We conclude that with dual energy CT it is possible to determine the composition of renal calculi in vivo non-invasively.

Keywords: Dual energy CT, Diabetes Hypertension Obesity

Introduction

Identification of composition of renal calculus plays a significant role in its treatment. Dual energy CT (DECT) KUB helps to distinguish between uric acid and non-uric acid renal calculi.[1,2]The successful treatment of urolithiasis is largely based on the stone composition especially uric acid stones which can be managed medically.[3-5] An early diagnosis and treatment can therefore significantly alter the outcome of the disease.[6]

Hence, the present study was aimed at establishing the composition of renal calculi in patients presenting with clinical features of renal calculi using DECT and Comparing the results post operatively with biochemical qualitative analysis of the renal calculi obtained surgically.

Materials And Methodology

Prospective observational study: The study was conducted in the Department of Radiology, SDMCMSH, Dharwad using128 slice single source dual energy CT scanner from 2019- 2021. Forty patients were selected for the study. After the clinical examination of the patients with a written and informed consent, they were subjected to Dual energy-CT evaluation of KUB. The images were processed choosing a dual energy protocol. Post processing, the images were interpreted for presence of renal calculi marked as blue (calcium containing), red (uric acid) and cysteine (yellow).

Results

Table 1: Distribution of age

Age in Years	Frequency	Percentage
30–40	16	40.0
40 –50	11	27.5
50 –60	10	25.0
Above60	3	7.5
Total	40	100.0

We could observe that the patients aged between 30 to 40 years were more.

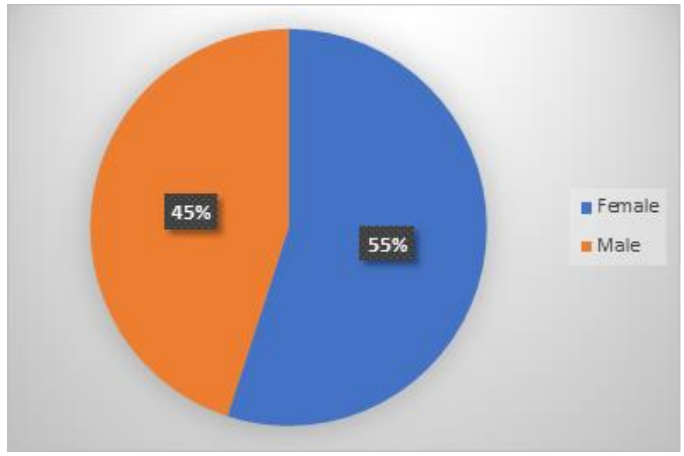

Figure 1: Distribution of Gender

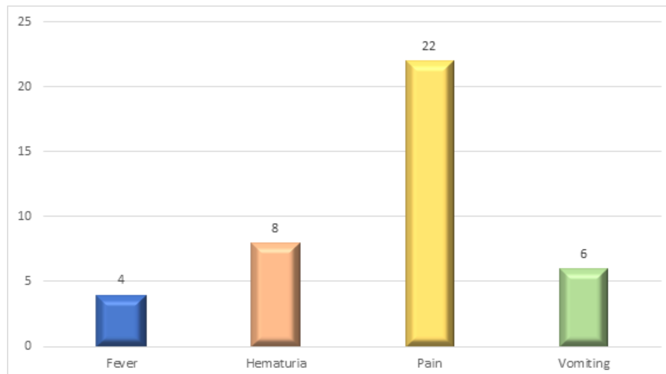

Figure 2: Distribution of Chief complaints

Of all the cases, 55% (22/40) of them were suffering from pain on either side of the lumbar region followed by 20% (8) with hematuria and the distribution of other symptoms was as above

Table 2: Distribution of Comorbid conditions

Comorbid	Frequency	Percent
Diabetes	10	25.0
Hypertension	4	10.0
Obesity	4	10.0
Nil	22	55.0
Total	40	100.0

Out of 18 patients with underlying comorbid conditions, 10 were diabetic and four each were presented with hypertension and obesity.

Table 3: Type of stones of in vivo analysis by dual energy CT

In vivo	Frequency	Percent
Calciumhydroxyapatite	4	10.0
CalciumOxalate	20	50.0
Cysteine	7	17.5
UricAcid	9	22.5
Total	40	100.0

Out of the 40 patients in our study who were clinically suspected cases/known cases of renal calculi, calcium oxalate was seen in 20 cases compromising 50% of total cases. Next common type was uric acid stone among 22.5% followed by cysteine and calcium hydroxyapatite among 17.5% and 10%respectively.

Table 4: Types of Stones on biochemical analysis

Ex vivo	Frequency	Percent
Calciumhydroxyapatite	4	10.0
CalciumOxalate	19	47.5
Calciumphosphate	1	2.5
Cysteine	6	15.0
Mixedstone	1	2.5
UricAcid	9	22.5
Total	40	100.0

Out of 40 cases, majority of them were identified to be having Calcium oxalate stone, accounting for about 19 (47.5%), followed by 9 (22.5%) with uric acid. 6 (15%) and 4 (10%) were identified with Cysteine and Calcium hydroxyapatite. One each were found with Calcium phosphate and Mixed type.

Table 5: Comparison between of stones identified by dual energy CT in in-vivo analysis and type of stones identified by ex vivo chemical analysis in same patient.

Comparison between Ex vivo with In vivo										
			In vivo				Total	χ 2 - value	p-value
			Calcium hydroxyapatite	Calcium Oxalate	Cysteine	Uric Acid			
Ex vivo	Calcium hydroxyapatite	Count	4	0	0	0	4	120.000	0.0005 **
		%	10.0%	0.0%	0.0%	0.0%	10.0%		
	Calcium Oxalate	Count	0	19	0	0	19		
		%	0.0%	47.5%	0.0%	0.0%	47.5%		
	Calcium phosphate	Count	0	1	0	0	1		
		%	0.0%	2.5%	0.0%	0.0%	2.5%		
	Cysteine	Count	0	0	6	0	6		
		%	0.0%	0.0%	15.0%	0.0%	15.0%		
	Mixed stone	Count	0	0	1	0	1		
		%	0.0%	0.0%	2.5%	0.0%	2.5%		
	Uric Acid	Count	0	0	0	9	9		
		%	0.0%	0.0%	0.0%	22.5%	22.5%		
Total		Count	4	20	7	9	40		
		%	10.0%	50.0%	17.5%	22.5%	100.0%		
**Highly Significant p<0.01level									

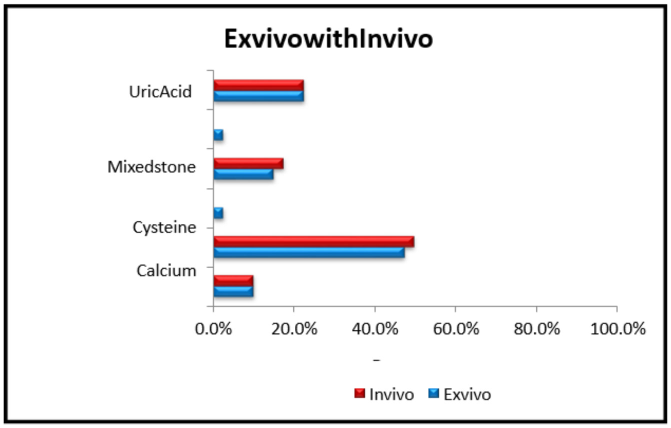

Figure 3: Comparison between the type of crystals In-vivo and Ex-vivo

Below are the Dual CT images obtained from our study population

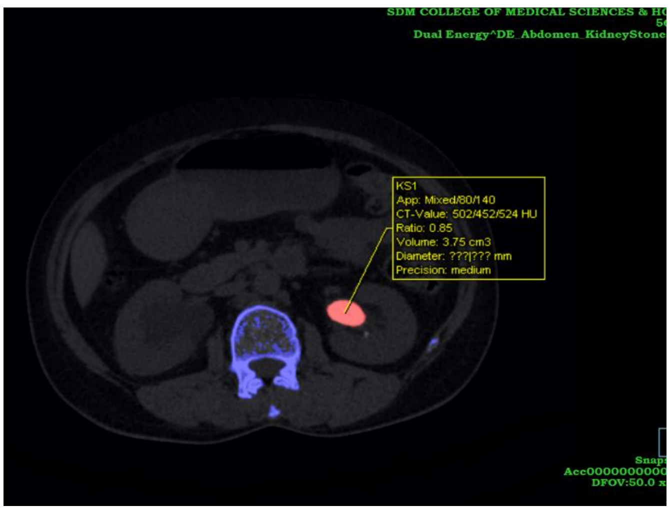

Figure 4A: Uric acid crystals

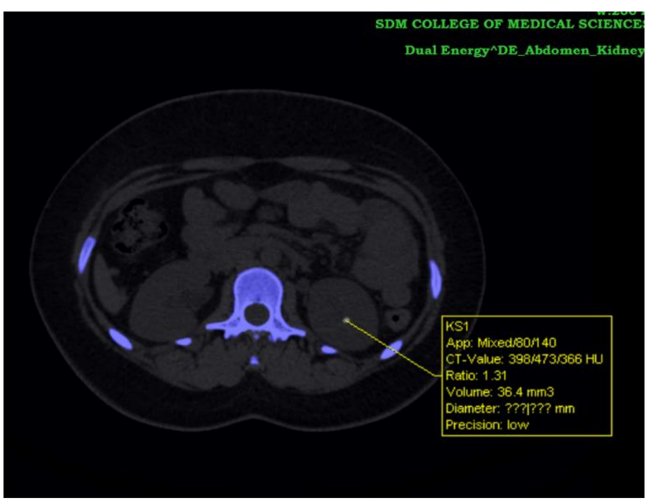

Figure 4B: Cysteine crystals

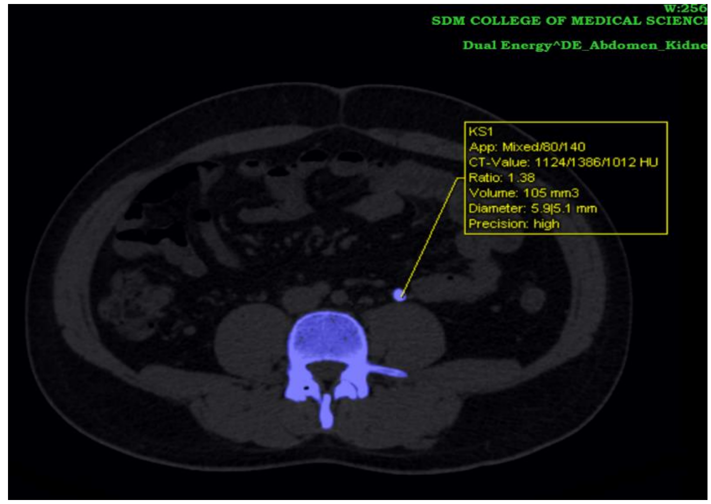

Figure 4C: Calcium Oxalate crystals

Discussion

In our study, a total of 40 cases of renal stones in reference to relevant demographic details. The type of stone were analyzed in vivo by dual energy CT and the same stones were subjected to chemical analysis after surgical retrieval to find out whether dual energy CT was accurate in diagnosis of nature of renal stones. Thereby this study was done to eliminate the unnecessary need for surgical intervention in patients with that type of renal stone which was amenable to medical treatment.

Images were acquired in dual energy CT protocol using 128 slice single source dual energy CT scanner of Siemens Somatom.[7] In our study of 40 patients, most of the patients with renal stones were found in middle age group (30 yrs to 50 yrs) ie 67.5%. Mean age of occurrence of renal stone was found to be 44.8 years.

Risk factors like obesity, diabetes and less water intake are found to play a very important role in development of renal stones. The most common chief complaint seen in our patients was loin pain. Nearly 22 people (55 %) were found to have loin pain. Most common comorbidity associated with renal stone patients was diabetes (25%).Hence, diabetic patients must be screened for renal stones. In our study compromising of 40 cases most common type of stone was calcium oxalate seen in 20 cases.

Compromising 50% of total cases. Next common type was uric acid stone (22.5%) followed by cysteine (17.5%) and calcium hydroxyapatite (10%) respectively. When the same stones were subjected to exvivo chemical analysis one of the calcium oxalate stone came to be calcium phosphate and one of the cysteine stone came out to be mixed stone. Thus, out of 40 stones 38 stones were found to have the same result in exvivo chemical analysis as that of invivo analysis by dual energy CT. Thus, accuracy of dual energy CT in diagnosis of renal stones was found to be 95%. Thereby reducing the unnecessary surgical intervention in stones that are amenable to medical treatment when identified preoperatively.

Thus, dual energy CT in diagnosis of renal stones was found to be significant. Similarly, Daniel boll et al gave the dual energy behavior of different renal calculi. Uric acid calculi (453 to 629 HU for low energy CT, 443 TO 615 HU for high energy CT). For cystine calculi (725 to 832 HU for low energy CT,513 to 747).[8]

Also, Graser et al (2008) conducted the study to determine the accuracy of dual energy CT in characterization of renal stone and ureteral stones. Results showed that DECT was able to differentiate uric acid calculi from other calculi. In dual energy CT calculi were displayed in specific colours.Uric acid in red colour and calcified stones in blue colour. Thus, with dual energy CT uric acid, cystine, struvite and mixed renal calculi can be differentiated from other types of renal stones invitro and in vivo. Thus, dual energy CT was very useful in identifying uric acid calculi in vivo which can be treated pharmacologically,hence avoiding unnecessary surgery.[9]Another trial by Primak et al (2009) also showed dual energy CT had 100% accuracy in diagnosis of uric acid calculi from other calculi.[10]

In the Daniel T boll et al (2009) pilot study showed that DE mutidetector CT with advanced post processing techniques improves characterization of renal stone composition beyond that achieved with single energy multi detector CT acquisitions with basic attenuation assessment.[8] Giorgio ascent et al (2010) was a study done on 39 patients with suspected renal colic in which ureteral stones were shown at low dose unenhanced CT were enrolled. Correct chemical composition was obtained by dual energy analysis in all 24 ureteral calculi.[11]Paulstolzman et al (2010) concluded that DECT detected 110/180 patients (61%) with renal stone disease. Sensitivity, specificity, PPV, and NPV for uric acid stone were 89%,98%,95% and 98%.[12] Limitation of the present study is, we could not assess the diagnostic accuracy. Also, the lesser sample size.

Conclusion

We conclude that with dual energy CT it is possible to determine the composition of renal calculi in vivo non-invasively. Therefore, this helps in deciding the modality of treatment. Whether the stone is amenable to medical management or requires ESWL or surgical intervention can be determined preoperatively. This helps to reduce the unnecessary financial burden and is found to be time saving. It is also found to reduce the recurrence rate of the stones in future.

References

1. McGrath TA, Frank RA, Schieda N, Blew B, Salameh JP, Bossuyt PMM, McInnes MDF. Diagnostic accuracy of dual-energy computed tomography (DECT) to differentiate uric acid from non-uric acid calculi: systematic review and meta-analysis. Eur Radiol. 2020 May;30(5):2791-2801.

2. Primak AN, Fletcher JG, Vrtiska TJ, Dzyubak OP, Lieske JC, Jackson ME, Williams JC Jr, McCollough CH. Noninvasive differentiation of uric acid versus non-uric acid kidney stones using dual-energy CT. Acad Radiol. 2007 Dec;14(12):1441-7.
3. Strohmaier WL. Recent advances in understanding and managing urolithiasis. F1000Res. 2016 Nov 8;5:2651.
4. Miller NL, Lingeman JE. Management of kidney stones. BMJ. 2007 Mar 3;334(7591):468-72.
5. Leslie SW, Sajjad H, Murphy PB. Renal Calculi. [Updated 2023 Mar 11]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK442014/
6. Mercimek MN, Ender O. Effect of urinary stone disease and its treatment on renal function. World J Nephrol. 2015 May 6;4(2):271-6.
7. Chen Y, Xue H, Jin ZY, Zhang J, Sun H, Wang X, Zhang ZH et al. 128-slice acceletated-pitch dual energy CT angiography of the head and neck: comparison of different low contrast medium volumes. PLoS One. 2013 Nov 19;8(11):e80939.
8. Boll DT, Patil NA, Paulson EK, Merkle EM, Simmons WN, Pierre SA et al. Renal stone assessment with dual-energy multidetector CT and advanced postprocessing techniques: improved characterization of renal stone composition--pilot study. *Radiology*. 2009:813–820.
9. Graser A, Johnson TR, Bader M, Staehler M, Haseke N et al. Dual energy CT characterization of urinary calculi: initial in vitro and clinical experience. Invest Radiol. 2008 Feb;43(2):112-9.
10. A. N. Primak, J. G. Fletcher, T. J. Vrtiska et al., “Noninvasive differentiation of uric acid versus non-uric acid kidney stones using dual-energy CT,” Academic Radiology, vol. 14, no. 12, pp. 1441–1447, 2007
11. Ascenti G, Siragusa C, Racchiusa S, Lelo I, Privitera G, Midili F et al. Stone-Targeted Dual-Energy CT: A New Diagnostic Approach to Urinary Calculosis. 2010;195(4): 1-4
12. Stolzmann, P, Leschka, S, Scheffel, H. Characterization of urinary stones with dual-energy CT: improved differentiation using a tin filter. Invest Radiol 2010; 45: 1–6.