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Performance of Low Dose Non Enhanced Multidetector CT in Evaluation of Urinary Calculi

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Abstract
Nephrolithiasis is a chronic recurrent problem and it is increasing in incidence in younger generation, patients are getting exposed repetitively to CT (Computed tomography) radiation with its attendant radiation hazards .Hence CT dose reduction technique happens to be the need of the hour to reduce the dose burden to the patient .So it is necessary to tailor a new and finer protocol with reduced dose without compromising optimum image quality.
Aims: *To assess the efficiency of low dose MDCT (Multidetector Computed tomography) in detecting urinary calculus when compared to standard MDCT.*
Methods and Material: *This is a prospective cross sectional study of 52 adult patients, carried on Multidetector 16 slice CT scanner-G E Bright speed elite over a period of 18 months from November 2016 to May 2018. All the patients who were advised CT urogram or CT KUB in whom urinary calculus was detected by MDCT-KUB (kidney, ureter and bladder) using an average tube potential of 120 kVp and tube current of 270- 350 mAs with a slice thickness of 5mm were selected and these patients were resubjected to low dose CT at the level of urinary calculus by using 100 kVp and 100 mAs with a slice thickness of 5 mm and reconstructed at 1.25 mm.*
Results: *The mean stone size in standard dose is 13.395 mm and in low dose is 13.361 mm with no significant difference.*
Mean CTDivol (Computed tomography dose index) in standard and low dose are respectively are 13.876 mGy and 2.796 mGy with average dose reduction by 79 .92 % in low dose.
Conclusions: *Low dose CT was found to be equally sensitive with equal positive predictive value in the detection and localisation of stones when compared to standard dose CT. At the same time low dose protocol helped to reduce patient radiation dose by an average of 79.92%. Since urolithiasis is a recurring disease and patients are frequently subjected to repeat CT examinations, the present low dose CT protocol will help to reduce cumulative radiation dose to the patient without compromising the sensitivity.*
Keywords: *CT dose index, Low dose CT, radiation dose, renal calculus, urolithiasis.*

Introduction

Renal calculus disease is a common clinical ailment encountered in daily practice in both sexes of all age groups, most common in middle age people. It has a high recurrence rate[1] with an increasing trend towards affecting the younger generation[2]. It is more common in males[3].

Its incidence is increasing in both developed and developing countries due to changes in socioeconomic conditions.

Various imaging modalities are currently available for evaluation of urolithiasis

1. X-Ray KUB 2.Ultrasound 3 Intravenous Urography 4.MDCT (Multidetector Computed tomography)

X-Ray KUB- has reduced sensitivity (45-58%) and specificity (69—77%) [4] because of overlying bowel gas, radiolucent stones, extrarenal and extra ureteral calcifications.

Ultrasound– has its own limitation in case of morbidly obese patients and gaseous abdomen. It is more of operator dependent investigation.

X- RAY KUB with Ultrasound- sensitivity 96% specificity 51%[4]

IVU-has sensitivity 85.2% specificity 90.4%[4] .Its limitations are

- Missing small stones.
- Edema or swelling at the vesicoureteric junction after the passage of stones mimicking the appearance of a retained stone.
- Risks associated with intravenous contrast.
- The study might be limitation by inadequate bowel preparation, bowel ileus, swallowed air and technical variability.
- Inconvenience of a long filming sequence.

MDCT-Currently non-contrast CT (NCCT) is considered first-line imaging study[4] for evaluation of patients with acute flank pain and suspected stone because it overcomes the above limitations. It is sensitive even in cases of small radiolucent stones and even in obese patients.

Sensitivity-95 to 98%[4]

Specificity-96 to 98% [4]

CT KUB is recognised as the best clinical imaging modality for patients with suspected urolithiasis as per the **ACR (America College of radiology) Appropriateness Criteria**.[5]

As low as reasonably achievable **(ALARA**) principle should be followed while making dose reduction and unnecessary radiation exposure._

Effective radiation dose can be optimized by decreasing tube potential, automatic current modulation, and CT post processing.[6]

- Pierre-Alexandre Poletti et al (2007) evaluated one hundred and twenty-five patients (87 men, 38 women; mean age, 45 years) who were admitted with suspected renal colic and underwent both abdominal low-dose CT at 30 mAs and standard-dose CT at 180 mAs.

  In patients with a BMI of <30, low-dose CT achieved a sensitivity of 95% and a specificity of 97% for detecting ureteric calculi. In patients with a BMI of <30, low-dose CT was 86% sensitive for detecting ureteric calculi of <3 mm and 100% sensitive for detecting calculi of >3 mm. Low-dose CT was 100% sensitive and specific for depicting non -urinary tract related disorders[7].
- William Sohn et al (2013) performed low dose CT (50-150mA) versus standard dose CT(200-500mA) for determination of stone size, density and skin to stone distance with results showing no significant difference but with effective radiation dose reduction from 23 to 6 mSv (73% dose reduction) [8].

So the present study is aimed to assess the efficiency of low dose MDCT in detecting urinary calculus when compared to standard MDCT and to evaluate

a. Sensitivity and specificity of low dose MDCT in detecting and localisation of urinary calculus.
b. Comparison of mean Hounsfield units and correlating with biochemical report wherever possible.
c. Assessing CTDi volume (Computed tomography dose index) and percentage dose reduction.

Subjects and Methods

- This is a prospective cross sectional study of 52 adult patients carried on Multidetector 16 slice CT scanner-G E Bright speed elite over a period of 18

months November 2016 to May 2018 in Department of Radiodiagnosis, Kasturba medical college, Ambedkar circle, Mangalore, Manipal academy of higher education (MAHE).

- Assuming Sensitivity -97% &Specificity-95%[1] with confidence interval 95% and power 90%.
- SAMPLE SIZE n=52 based on formula

$$n=\frac{Z\alpha 2\times Sn(1-Sn)}{L2 \times P}$$

[Zα: 1.96 L : Error P : Prevalence]

- Statistical analysis was done by kappa statistics –sensitivity and positive predictive value.
- All the patients who were advised CT urogram or CT KUB in whom urinary calculus was detected by MDCT-KUB using an average tube potential of 120 kVp and tube current of 270- 350 mAs with a slice thickness of 5mm were selected and these patients were resubjected to low dose CT at the level of urinary calculus by using 100 kVp and 100 mAs with a slice thickness of 5 mm and the images are later reconstructed at 1.25 mm.

Standard MDCT KUB protocol in the department:

- Tube voltage 120kVp
- Tube current 270-350 mAs
- Slice thickness 5 mm
- Reconstruction 1.25mm

LOW DOSE CT protocol in my present study:

- Tube voltage 100 kVp for average BMI
- Tube current 100 mAs
- Slice thickness 5 mm
- Reconstruction 1.25mm

Inclusion and Exclusion Criteria

Inclusion criteria

- All patients with suspected renal colic who were advised CT urogram or CT KUB and the initial plain CT has showed urinary calculus .

Exclusion criteria

- Pregnancy
- Children
- BMI$\geq$30kg/m^2

Results

Our study included 36 are male and 16 are female with male:female ratio-2:1

Our study included patients of age group ranging from 19 to 78 years with mean age group 47 years.

In our study based on location the highest percentage of stones are found in kidney followed by ureter.

The mean stone size in high dose is 13.395 mm and in low dose is 13.361 mm with no significant difference.

Mean density of stone in standard dose CT and in low dose CT is 876.5 and 905.1 HU respectively with no significant difference.

Mean CTDivol in high and low dose are respectively are 13.876 mGy and 2.796 mGy with average dose reduction by 79 .92 % in low dose.

Out of 52 cases, stone retrieval was done for 20 cases for which follow up was done

Most of the stones were mixed stones with composition of calcium, oxalate, ammonia and uric acid.

We came across one pure uric acid stone which shows a density of 311 HU.

Out of the 20 cases Calcium containing stones were 16 with density ranging from 333HU to 1565 HU, which included staghorn, pelvic, ureteric and VUJ calculi .

Three mixed stones of uric acid and oxalate composition of density ranging from 634 to 1455 HU were found.

Density of stones helps us to determine the calculi which respond to extracorporeal shock wave lithotripsy, stones that are likely to fragment easily from those that would require a greater number of shock waves. Lesser the density of calculus, easier to fragment by extracorporeal shock wave lithotripsy [9].

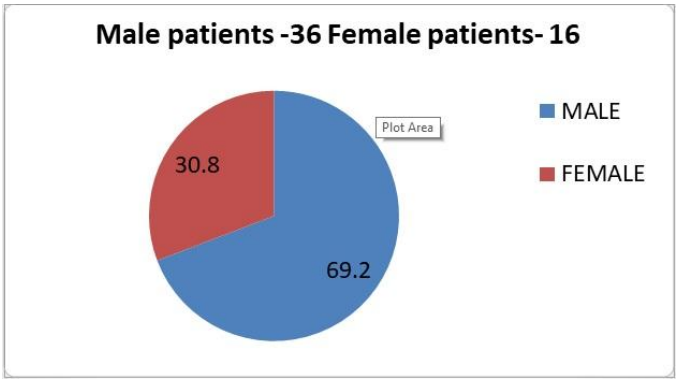

Figure 1 Pie Chart Representing Sex Distribution of the Patients

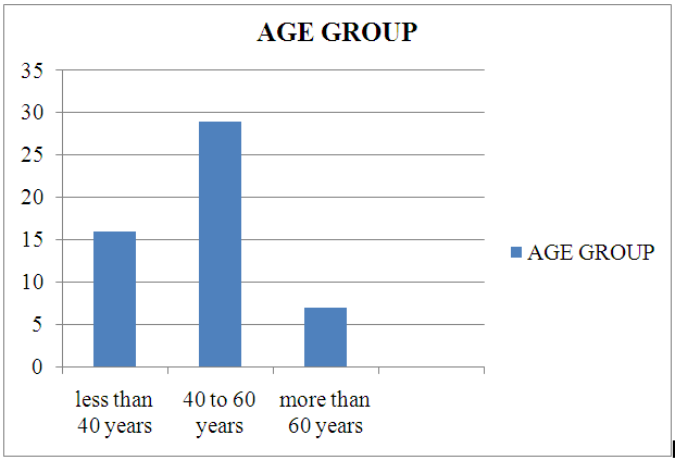

Table 1 Age Distribution of the Patients

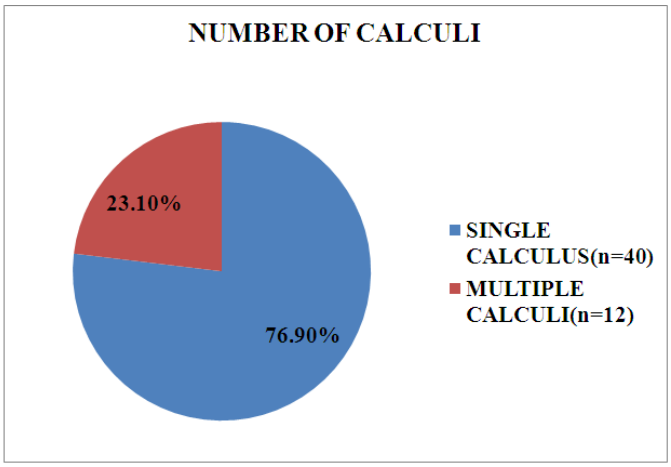

Figure 2 Representing the ratio of Patients with single and Multiple Calculi in the Study Group

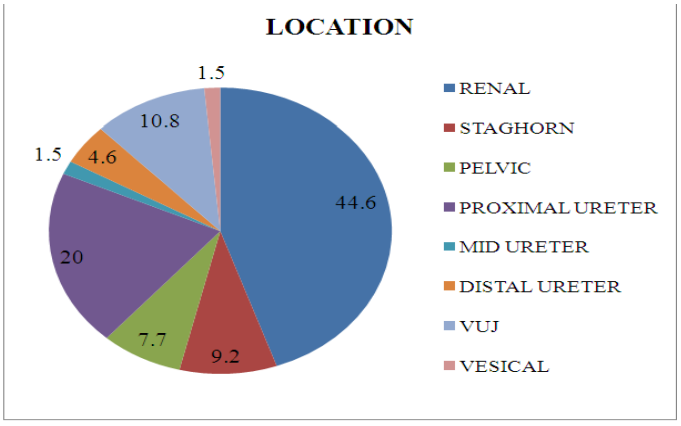

Figure 3 Representing the Location of Stone

Table 2 Represents Mean, Median, and Range of Calculus in Standard and Low Dose Protocols.

	SIZE (mm)	SIZE (mm)	DENSITY (HU)	DENSITY (HU)	CTDi vol (mGy)	CTDi vol (mGy)
	SD	LD	SD	LD	SD	LD
N Valid	64	64	64	64	52	52
Mean	13.395	13.361	876.453	905.109	13.876	2.796
Median	9.450	9.800	885.500	943.500	13.800	3.000
Range	56.300	56.000	1316.000	1406.000	7.180	1.200
Minimum	3.00	3.000	185.000	227.000	10.090	1.800
Maximum	59.000	59.000	1501.000	1633.000	17.270	3.000

SD-Standard Dose
LD Low Dose

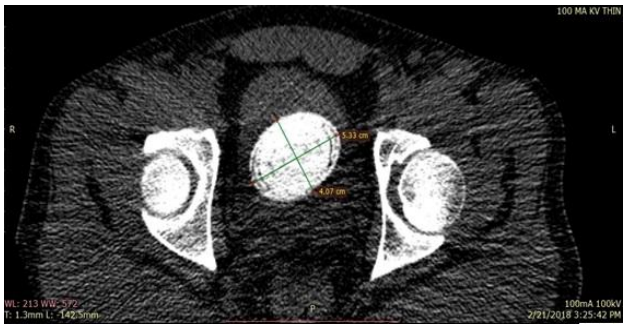

Fig 4.1 Low dose CT – Laminated vesical calculus measuring 53x40 mm

Fig 4.2 Standard dose CT -Laminated vesical calculus measuring 54x41 mm

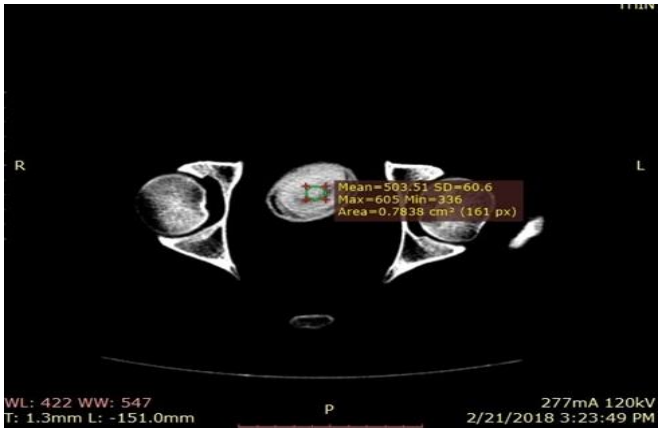

Fig 4.3 Standard dose CT –Mean density of vesical calculus is 503 HU

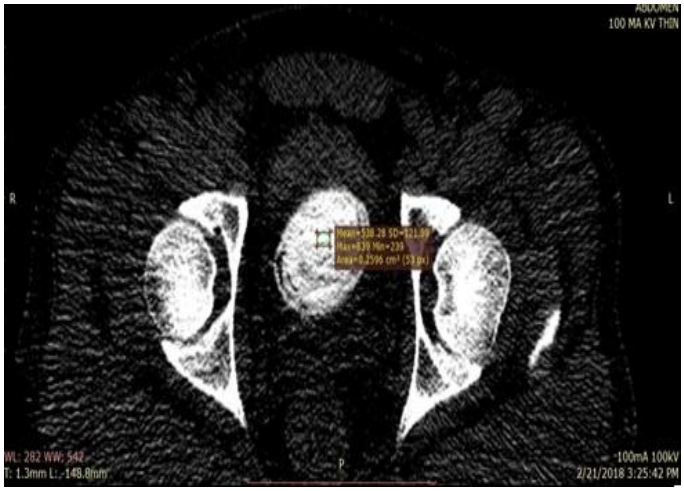

Fig 4.4 Low dose CT – Mean density of the vesical calculus is 538HU

ABDOMEN
Dose Report

Dose Report

Series	Type	Scan Range (mm)	CTDIvol (mGy)	DLP (mGy-cm)	Phantom cm
1	Scout	-	-	-	-
2	Helical	157.250-1222.250	13.81	273.39	Body 32
3	Helical	1105.000-1180.000	1.80	17.57	Body 32
			Total Exam DLP:	290.95	

1/1

Fig 4.5 CTDIvol of standard dose CT is 13.81 mGy and of low dose CT is 1.8 mGy respectively which is 86% dose reduction

Fig 5.1 Standard dose CT – Left proximal ureteric calculus measuring 6.5x5.6 mm

Fig 5.3 Standard dose CT – Left proximal ureteric calculus of density 884 HU

Fig 5.2 Low dose CT – Left proximal ureteric calculus measuring 6 x 6.7 mm

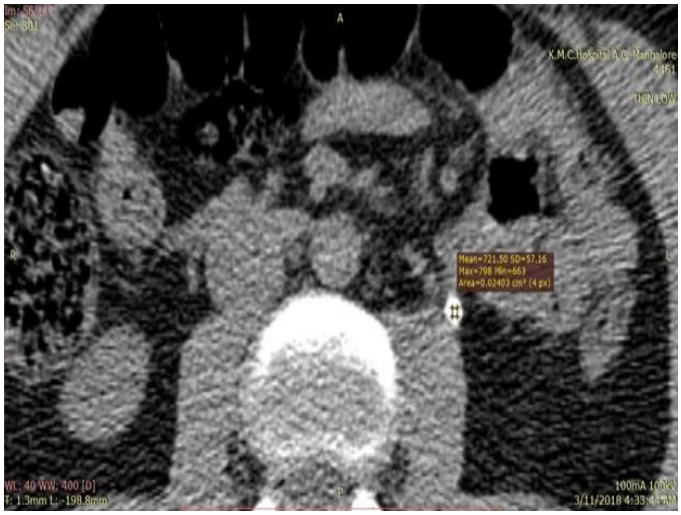

Fig 5.4 Low dose CT – Left proximal ureteric calculus of density 721 HU

Dose Report

Series	Type	Scan Range (mm)	CTDIvol (mGy)	DLP (mGy-cm)	Phantom cm
1	Scout	-	-	-	-
2	Helical	127.500-1517.500	13.81	722.35	Body 32
3	Helical	1207.000-1277.000	3.00	30.88	Body 32
			Total Exam DLP:	753.23	

1/1

Fig 5.5 CTDIvol of standard dose CT is 13.8mGy and of low dose CT is 3 mGy respectively which is 78 % dose reduction

Discussion

The present study will help us to develop a low dose CT protocol for renal calculus disease while maintaining the diagnostic quality of the image with effective dose reduction to the patient.

We can manipulate various technical factors during CT acquisition to bring a substantial reduction in radiation dose. The relationship between the tube current and radiation dose is proportional which implies that reduction of mAs by 50% will result in reduction of radiation dose by 50 %. Radiation dose is directly proportional to kV2, so significant reduction in dose can be achieved with relatively small decrements in tube potential. Altering slice thickness and pitch can also result in dose reduction.

In the present study, I have reduced tube current as well as tube potential for dose reduction from 270-350mAs to 100 mAs and from 120 kVp to100 kVp respectively.

Standard MDCT KUB protocol in the department:

- Tube voltage 120kVp
- Tube current 270-350 mAs
- Slice thickness 5 mm
- Reconstruction 1.25mm

LOW DOSE CT protocol in my present study:

- Tube voltage 100 kVp for average BMI
- Tube current 100 mAs
- Slice thickness 5 mm
- Reconstruction 1.25mm

In our present study, the CTDI using low dose CT protocol was found to be much lower when compared to that of standard dose CT protocol.

Radiation Dose Calculation

E= DLP x k Where E = Effective Dose in mSv, DLP = Dose Length Product in mGyxcm

k = conversion coefficient in mSv/mGyxcm = .015 for abdomen10

CTDI vol= Approximates the average dose in the acrylic dosimetric phantom during a helical CT scan that covers the entire phantom.

Jiang Licheng et al[10] compared unenhanced low-dose spiral CT localization with unenhanced standard-dose spiral CT in patients with upper urinary tract calculi for minimally invasive percutaneous nephrolithotomy (MPCNL) treatment. They performed standard and low dose CT protocol with following parameters 120 kV, 100 mAs and 120 kV; 25 mAs respectively .

They determined the size and location of calculi in the urinary system and the volume CT dose index (CTDIvol) and scan length (L) The effective dose (E) of CT scan was obtained by the following formula: E= CTDIvol×L×f (where f is a specific conversion factor, and for which the f of abdominal region is 0.015) in both low and standard dose CT.

Effective dose (mSv) of low dose CT protocol is 0.88 ± 0.10 where as for standard protocol it is 3.58 ± 0.38 .They found low-dose CT was 100 percent sensitive and 100 percent specific for depicting the

location of the renal and ureteric calculus with significant dose reduction.

In my present study I have used two separate protocol settings as above for renal calculus disease with standard dose and low dose .Under low dose protocol focused study with decreased scan length at the level of calculi was done . So, specificity and negative predictive value could not be assessed.

In the conducted study, our results demonstrated a mean average reduction of 79.92 % decrease in CTDIvol in low dose CT KUB protocol when compared to standard dose CT protocol with 100% sensitivity and 100% positive predictive value in detecting the calculus and its location.

Conclusion

Low dose CT was found to be equally sensitive with equal positive predictive value in the detection and localisation of stones when compared to standard dose CT. At the same time low dose protocol helped to reduce patient radiation dose by an average of 79.92 %. Since urolithiasis is a recurring disease and patients are frequently subjected to repeat CT examinations, the present low dose CT protocol will help to reduce cumulative radiation dose to the patient without compromising the sensitivity.

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