Journal Homepage: -www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI:10.21474/IJAR01/14931
DOI URL: http://dx.doi.org/10.21474/IJAR01/14931

RESEARCH ARTICLE

A STUDY OF URINARY TRACT ABNORMALITIES: ROLE OF LOW DOSE MDCT UROGRAPHY

Dr. Shruti Gupta[1], Dr. Kushal Gehlot[2], Dr. N.K. Kardam[3] and Dr. Manoj Sharma[4]

1. Resident Doctor, Department of Radiodiagnosis, R.N.T.Medical College, Udaipur.
2. Professor& HOD, Department of Radiodiagnosis, R.N.T.Medical College, Udaipur.
3. Senior Professor, Department of Radiodiagnosis, R.N.T.Medical College, Udaipur.
4. Resident Doctor, Department of Radiodiagnosis, R.N.T.Medical College, Udaipur.

Manuscript Info

Manuscript History
Received: 21 April 2022
Final Accepted: 24 May 2022
Published: June 2022

Key words:-
MDCTU, Low Dose, Standard Dose Protocol, Radiation Dose, Image Quality

Abstract

Introduction: Computed Tomography (CT) urography is more accurate in detection of renal masses, urinary tract tumors, inflammatory lesion, calculi and other causes of urinary tract obstruction compared with intravenous urography. The standard single bolus MDCT Urography protocol comprises three to four phases, consists of non-contrast, corticomedullary, nephrographic and excretory phases. A major disadvantage is a high radiation dose, which is 8-10 times higher than an IVP examination. In comparison, an split-bolus, dual-phase technique scans the urinary system in the non-contrast and combined nephrographic-excretory phases. This study aimed to compare the total CT radiation dose of patient and image quality in standard MDCTU protocol and low dose MDCTU protocol.

Methodology: In this hospital based prospective study total 100 patients (50 tests and 50 controls) were compared for radiation dose and subjective image quality assessment between standard dose MDCTU protocol [non contrast scan at 120kvp , followed by contrast enhanced corticomedullary phase and excretory phase] and low dose MDCTU protocol (non contrast scan (at 80 kvp), followed by contrast enhanced synchronus corticomedullary phase and excretory phase acquisition by using split bolus contrast administration technique) .

Result: In the standard dose MDCTU protocol in unenhanced and enhanced phase, patients received mean net effective dose of 18.83 mSv and in the low dose protocol, patients received mean net effective dose of 9.06 mSv with significant 52% dose reduction (P value <0.001). In Standard dose protocol in unenhanced phase, optimal resolution in 82% patients, moderately grainy/poor resolution in 14% and significantly grainy/very poor resolution in 4% patients. In low dose protocol, optimal resolution in 64% patients, mild to moderately grainy/poor resolution in 22% and significantly grainy/very poor resolution in 14% patients with no significant difference in image quality in both protocol (P value>0.05). In low dose protocol, mild to moderately grainy/poor resolution images (22%) of unenhanced phase reviewed together with normal dose good qualitysynchronus corticomedullary and excretory phase images to diagnosis the almost same spectrum of pathology like standard dose protocol.

Corresponding Author:- Dr. Manoj Sharma
Address:- Resident Doctor, Department of Radiodiagnosis, R.N.T.Medical College, Udaipur.

Conclusion: In low dose MDCT Urography radiation dose reduction of approx 50% is possible with no significant difference in image quality in line to ALARA principle (As low as reasonably achievable), facilitating diagnosis of urological pathologies.

……

Introduction:-

In uroradiology[1] since last many years, the IVP was the most important uroradiological examination. CT, since the late 1980s and 90s were widely used in radiologic evaluation of the kidneys and urinary collecting system, including renal masses, infection, and trauma[2]. The introduction of multi-detector row CT (MDCT) allows to depict the renal collecting systems accurately through thinner section imaging, faster scanning, improved longitudinal spatial resolution, and the subsequent better quality of reformatted coronal images.[3-4] The most commonly described MDCT Urography protocol comprises a three-phase protocol, which typically consists of non-contrast (for the detection of hemorrhage and stones), nephrographic (for renal parenchymal evaluation), and excretory phases (for assessing the collecting system, ureters and urinary bladder).[5]

A major disadvantage of the multi-phase scanning techniques is high radiation exposure. Radiation dose from a MDCT Urography is 8 to 10 times higher than an IVP examination.[6]The reported radiation dose exposure for CTU examination ranges from 20 to 66 mSv, compared with a mean effective dose of 3.5-5 mSv for intravenous urography.

Different dose reduction approaches in CT examinations can be applied—by reduction in tube voltage (kV), tube current to time product (mAs) or by reduction in the number of phases. Chai et al proposed the use of a split-bolus technique that allows the reduction of radiation dose by reducing the total number of scanning phases to single common nephropyelographic phase with excretion of previous low volume injection of split bolus injection[7.] By eliminating the additional radiation exposure from additional phases, this technique clearly reduces the effective radiation dose. The split bolus technique has the potential to reduce both radiation dose and the number of images generated by MDCT Urography. Thus, optimization of CTU protocols is important for keeping patient doses as low as reasonable achievable (ALARA), consistent with diagnostic purpose.

Material And Methods:-

This hospital based prospective study was conducted on indoor and outdoor patients inDeptt. of Radiodiagnosis of R.N.T. Medical College, Udaipur during the period of one and half year from June 2020 to December 2021.

Total 100 patients (50 tests and 50 controls) were compared for radiation dose and subjective image quality assessment between standard dose MDCTU protocol and and low dose MDCTU protocol .Patient of any age and sex with complaints related to urinary system were included.Patient who does not give consent for study, or have allergy to iodinated contrast or renal function test value deranged were excluded. Ethical committee clearance was obtained from the institution's Ethical Committee (RNT/Stat./IEC/2020/409).

Method:-

In standard dose MDCTU protocol [non contrast scan (at 120kvp), followed by contrast enhanced corticomedullary phase and excretory phase].

In low dose MDCTU protocol (with split bolus technique) – after an initial noncontrast administration at 80 kVp, 30% of (dose calculation according to body weight of patient (1.5ml/kg) nonionic contrast materialwas infused intravenously and patient was allowed for remain on table for 6-7 min, contrast enhanced CT was then performed following the fast manual administration of rest of the 70% of dose of total nonionic contrast material following a delay of 20 seconds. Thus in a single "nephropyelographic phase" acquisition, the renal paremchyma (corticomedullary phase) and the collecting system, ureters and bladder (pyelographic phase) were assessed synchronously.

Total radiation dose was calculated by multiplying the DLP to Weighing factor in both contrast and test patients. In both group image quality was assessed subjectively, in respect of graininess.

Result:-

A Total of 100 patients in a group of 50 patients standard dose and 50 patients low dose protocol, fulfilling inclusion and exclusion criteria were recruited in this study. Obtained data entered in excel sheet of master chart and relavant observations were made in tabulated form on various parameters.

In our study, Maximum number of patient in low dose protocol belong to more than 60 year age group (26%) followed by 20-30 yr of age group (16%). Maximum number of patient in standard dose protocol belong to more than 60 year age group (24%) followed by 40-50 yr of age group (22%) (Table 1).

In low dose protocol, out of 50 patient 27 (54%) were male, followed by 23 (46%) female. In standard dose protocol, out of 50 patient 41 (82%) were male, followed by 9 (18%) female (Table 2).

In low dose protocol, maximum number of patients 17 (34%) were of renal calculi,UB neoplasm 8(16%) ureteric calculi 6(12%), Cystic renal disease 6(12%) ,Congenital anomalies 6 (12%), PUJ narrowing (8%), renal neoplasm 4(8%) Trauma 2(4%), followed by Infections 2(4%).

In Standard dose protocol, maximum number of patients were of 18 renal calculi (36%), ureteric calculi 12 (24 %), Cystic renal disease 8(16%), renal neoplasm 7(14%), Congenital anomaly 7 (12%), UB neoplasm 6(12%) , Infections 5(10%), PUJ narrowing 2(4%), followed by Trauma 1(2%) (Table 3).

There was significant difference in mean and SD of Net effective dose in unenhanced phase, between standard and low dose protocol, with 61% dose reduction. (P value <0.001) (Table 4).

There was significant difference in mean and SD of Net effective dose in unenhanced and enhanced phase, between standard and low dose protocol, with 52% dose reduction (P value <0.001) (Table 5).

In low dose protocol, optimal resolution found in 32 (64%) patients, mild to moderately grainy/poor resolution in 11(22%) and significantly grainy/very poor resolution in 7 (14%) patients.

In Standard dose protocol, optimal resolution found in 41 (82%) patients, moderately grainy/poor resolution in 7(14%) and significantly grainy/very poor resolution in 2 (4%) patients.

There was no significant difference in image quality between low dose protocol and standard dose protocol (P value>0.05) (Table 6)

Table no. 1:- Age wise distribution of patient in study.

Age Group (In years)	Low dose MDCTU Protocol	Standard dose MDCTU Protocol	Total
<10 yr	5(10%)	1(2%)	6(6%)
10-20 yr	6(12%)	3(6%)	9(9%)
20-30 yr	8(16%)	8(16%)	16(16%)
30-40 yr	6(12%)	7(14%)	13(13%)
40-50 yr	7(14%)	11(22%)	18(18%)
50-60 yr	5(10%)	8(16%)	13(13%)
>=60 yr	13(26%)	12(24%)	25(25%)
Total	50(100%)	50(100%)	100(100%)

Table 2:- Gender wise distribution of patients in study.

Gender	Low dose MDCTU Protocol	Standard dose MDCTU Protocol	Total
Female	23(46%)	9(18%)	32(32%)
Male	27(54%)	41(82%)	68(68%)
Total	50(100%)	50(100%)	100(100%)

Table no. 3:-Disease distribution of patient in both protocols.

Pathology	Low dose MDCTU Protocol (N-	Standard dose MDCTU

	50)	Protocol(N-50)
Renal calculi	17 (34%)	18 (36%)
Ureteric calculi	6 (12%)	12 (24%)
Congenital anomalies	6 (12%)	7 (14%)
PUJ narrowing	4 (8%)	2 (4%)
Renal vessel anatomical variation	4(8%)	3(6%)
Trauma	2 (4%)	1 (2%)
Infections	2 (4%)	5 (10%)
Cystic renal diseases	6 (12%)	8 (16%)
Renal neoplasm	4 (8%)	7 (14%)
UB neoplasm	8 (16%)	6 (12%)

Table no. 4:- Comparison of Net effective dose (mSv) in unenhanced phase in both protocols.

Protocol	NED Values (mSv) Mean	NED Values (mSv) SD	P value
NCCT Low dose MDCTU Protocol (N-50)	2.45	0.81	
Standard dose MDCTU Protocol(N-50)	6.30	0.85	<0.001

Table no. 5:- Comparison of total Net effective dose (mSv) in unenhanced & enhanced phase in both protocols.

Protocol	Total NED Values (mSv) Mean	Total NED Values (mSv) SD	P value
Low dose MDCTU Protocol (N-50)	9.06	2.33	
Standard dose MDCTU Protocol(N-50)	18.83	2.56	<0.001

Table no. 6:- Comparison of Image quality in unenhanced phase in both protocols.

Image quality in unenhanced phase	Low dose MDCTU Protocol (N-50)	Standard dose MDCTU Protocol(N-50)
Optimal resolution	32(64%)	41(82%)
Mild to Moderately grainy/poor resolution	11(22%)	7(14%)
Significantly grainy/very poor resolution	7(14%)	2(4%)
Total	50 (100%)	50 (100%)

Cases &Images

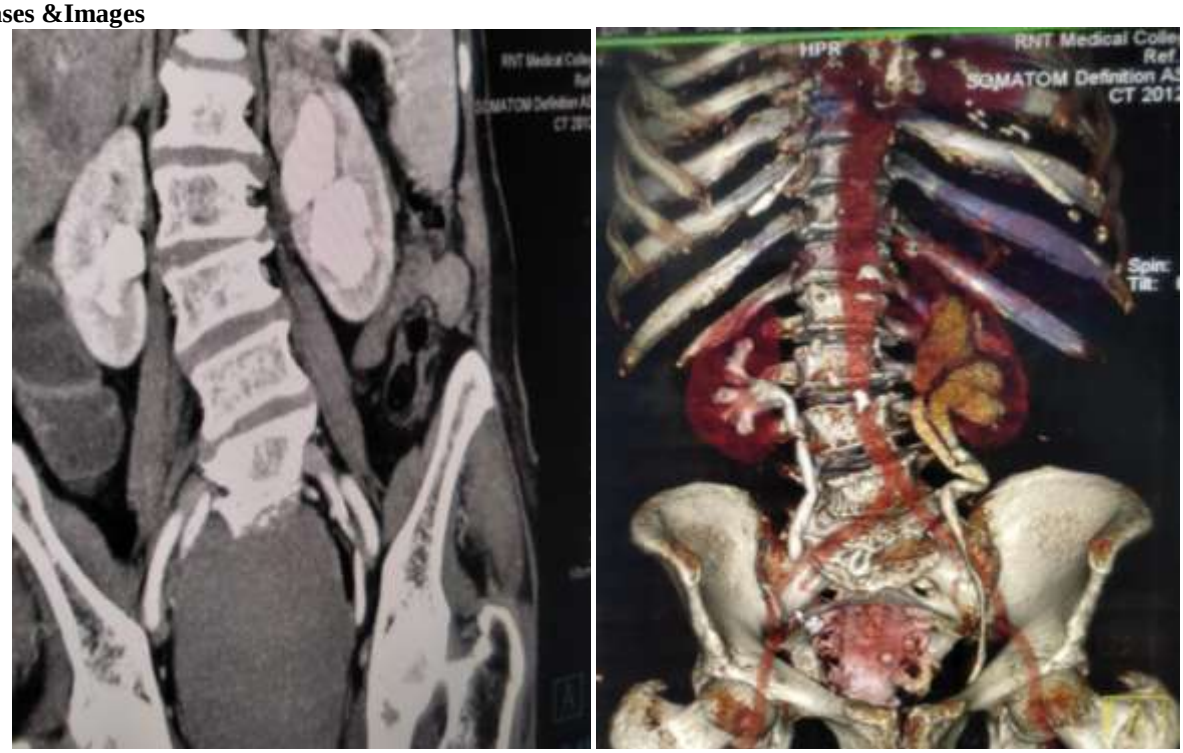

Figure 1:- Coronal MPR and VRT images in synchronus corticomedullary and pyelographic phase showing duplication of left pelvicalyceal system.

Figure 2:- Axial image in synchronus corticomedullary and pyelographic phase showing right renal pelviuretric junction narrowing.

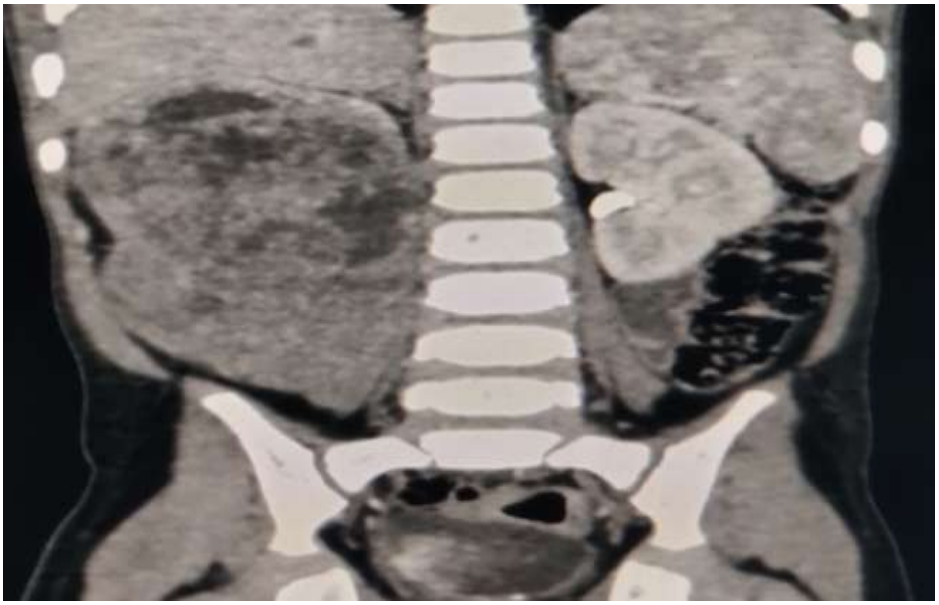

Figure 3:-Coronal MPR images in synchronus corticomedullary and pyelographic phase showing large heterogeneous hypodense mass in right renal fossa region with non separatevisualisation of right kidney likely renal malignant mass.

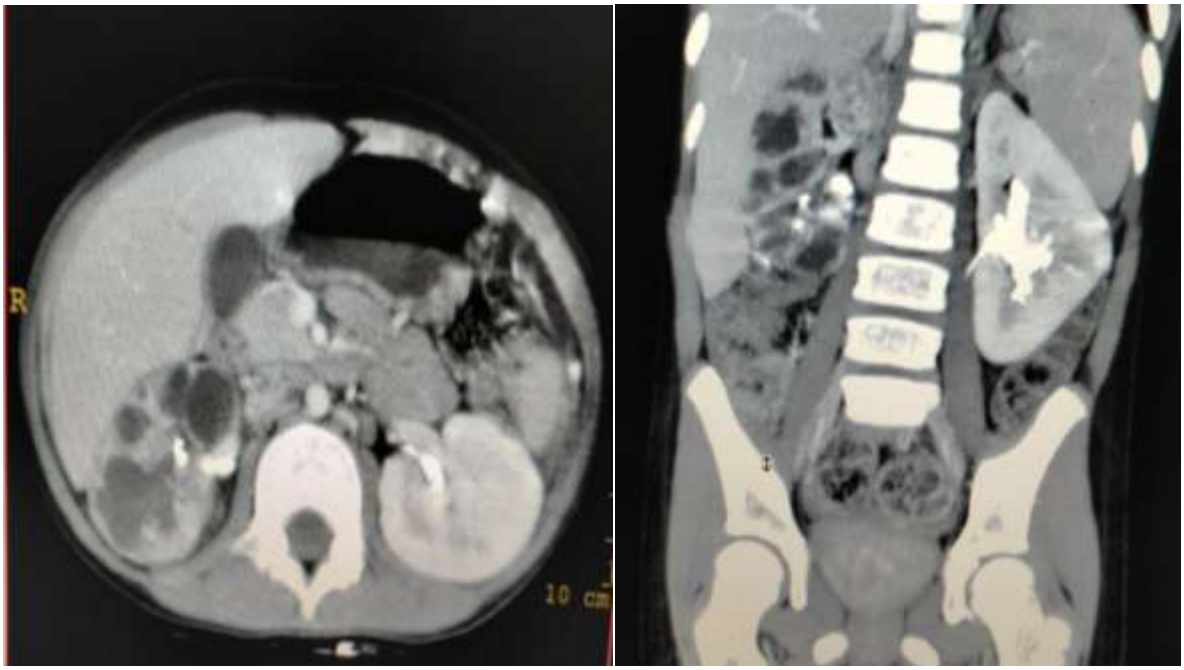

Figure 4:- Axial and coronal images in synchronus corticomedullary and pyelographic phase showing right pelvic calculus with moderate hydronephrosis.

Figure 5:- Axial image in contrast enhanced corticomedullary phase showing multiple calcific foci scattered in medulla of bilateral kidneys s/o medullary nephrocalcinosis.

Discussion:-

MDCT Urography has become the primary modality of choice for examination for the kidneys and urinary tract. The Standard MDCT Urography protocol comprises a three-phase & four phase protocol, which typically consists of non-contrast, corticomedullary, nephrographic, and excretory phases. High radiation exposure from MDCT compared with conventional excretory urography examination is biggest concern tampering the widespread use of CT urography in clinical practice particularly when performed in young patients or for follow up purposes. Different dose reduction approaches is being used like reduction in tube voltage, tube current to time product or by reduction in number of phases. Split-bolus CTU protocol comprises a biphasic protocol, which consist of unenhanced phase and combined nephropyelographic phase.

Radiation dose reduction by low voltage technique comparison:

In this study the standard dose MDCT Urography protocol (at 120 kVp), 50 patients received dose an average of 6.30 mSv and in the low dose protocol (at 80 kVp), 50 patients received an average of 2.45 mSv in a unenhanced phase with 61% dose reduction. **M.AL-Amin et al. (2015)[8]** found in their study that effective dose was reduced by more than 65 % using the 100-kV protocol and by more than 76 % with introduction of 80-kV protocol in unenhanced phase. **Yumi Yanaga et al. (2009)[9]**found in their study that the mean effective doses for 120 and 80-kVp scans were 7.0 and 2.9 mSv.

Radiation dose reduction by spilt bolus technique comparison:

In this study, DLP Value in enhanced phase by using single bolus protocol was 823.24 $mGycm^{-1}$ and by using single protocol DLP value reduced to 414.44 $mGycm^{-1}$with approx 50% dose reduction. In this study approx 50% dose reduction in DLP and 47% dose reduction by using split bolus protocol.

In this study in unenhanced and enhanced phase by using standard dose protocol total net effective dose was 18.83 mSv and by low dose protocol 9.06 mSv, with a significant reduction of 52% radiation dose. **Adityan R1 et al. (2021)[10]** the mean DLP value is 551 $mGycm^{-1}$ in contrast enhanced phase and 902 $mGycm^{-1}$ in delayed phase ,with 786 $mGycm^{-1}$ in synchronous corticomedullary and delayed phase with approx 68% dose reduction. **Li Jen Wang et al. (2021)[11]** concluded that reduction of DLP by 50% and NED by 45% occurs when split bolus technique applied.

Image quality assessment –

In this study low dose protocol, optimal resolution found in 32 (64%) patients, mild to moderately grainy/poor resolution in 11(22%) and significantly grainy/very poor resolution in 7 (14%) patients. In Standard dose protocol,

optimal resolution found in 41 (82%) patients, moderately grainy/poor resolution in 7(14%) and significantly grainy/very poor resolution in 2(4%) patients. There is no significant difference in image quality between low dose protocol and standard dose protocol (P value>0.05).

We found, that in unenhanced phase 4% images in standard protocol and 14% images in low dose protocol are of significantly grainy images with very poor resolution, obesity was most contributing factor .Obese habitus of patient lead to increased in image noise which result in poor image quality. This can be overcome by altering the tube voltage/tube current in such patients in order to achieve a clear image with a compromise of slightly higher radiation dose.

In low dose protocol, mild to moderately grainy/poor resolution images (22%) of unenhanced phase reviewed together with normal dose good quality synchronous corticomedullary and excretory phase images to diagnosis the pathology. In conclusion, after modifying the standard MDCT Urography (reducing kVp in unenhanced phase and using split bolus technique for corticomedullary phase) radiation dose reduction of approx 50% is possible with diagnosis of spectrum of disease (urolithiasis, cystic renal disease, renal and urinary neoplasm,congenitalanamoly), similar by diagnosis in standard dose MDCT Urography.

Limitations-

The single bolus and split bolus techniques were not performed for the same patient as it increases radiation exposure, which is ethically unacceptable. Hence, we cannot evaluate the superiority and inferiority of the techniques in our study. In the study there was no subject matching between the groups, possible confounding factors such as age, body mass index may alter either radiation dose, image quality and contrast enhancement, it was hoped that appropriate sample size could reduce any resultant bias.

While our study supports the opinion that image quality from a split bolus technique is comparable to those obtained from a single bolus technique, the diagnostic sensitivity for a lesion detected is urinary tract is not directly compared this was however not the aim of our study and also we were able to detect almost similar spectrum of urinary pathology compared to standard dose protocol.

Summary &Conclusion:-

This study concluded that the low dose MDCTU protocol by using low tube voltage and split bolus technique could be considered an effective tool for reducing radiation exposure to the patient for CT urography examination, particularly helpful for young patients and for follow up examinations. Use of this technique allows significant reduction in radiation dose without marked degradation of image quality in line to ALARA principle (As low as reasonably achievable), facilitating assessment of the similar spectrum of urinary tract pathologies. Therefore, the knowledge of this feasible technique, its applications and main limitations represents a powerful additional tool for radiologists.

References:-

1. Elkin M. Stages in the growth of uroradiology. Radiology. 1990 May;175(2):297-306
2. Smith RC, Rosenfield AT, Choe KA, Essenmacher KR, Verga M, Glickman MG, et al. Acute flank pain: comparison of non-contrast-enhanced CT and intravenous urography. Radiology. 1995 Mar;194(3):789-94.
3. Cowan NC, Turney BW, Taylor NJ, McCarthy CL, Crew JP. Multidetector computed tomography urography for diagnosing upper urinary tract urothelial tumour. BJU Int 2007; 99: 1363-1370
4. Caoili EM, Cohan RH, Inampudi P, Ellis JH, Shah RB, Faerber GJ, Montie JE. MDCT urography of upper tract urothelial neoplasms. AJR Am J Roentgenol 2005; 184: 1873-1881
5. Lang EK, Macchia RJ, Thomas R, Watson RA, Marberger M, Lechner G, 6.Gayle B, Richter F. Improved detection of renal pathologic features on multiphasic helical CT compared with IVU in patients presenting with microscopic hematuria. Urology 2003; 61: 528-532
6. David sutton, Philip j.A. Robinson, jeremyp.r. Jenkins, richard w. Whitehouse, paul l. Allan, peter wilde. Textbook of radiology and imaging;Seventh edition volume 2nd 2003,29,906
7. Chai RY, Jhaveri K, Saini S, Hahn PF, Nichols S, Mueller PR. Comprehensive evaluation of patients with haematuria on multi-slice computed tomography scanner: protocol design and preliminary observations. AustralasRadiol 2001; 45: 536-538Leusmann DB, Niggemann H, Roth S, von Ahlen H. Recurrence rates and severity of urinary calculi. Scand J Urol Nephrol 1995; 29: 279-2

8. M. Al-Amin, I. Dyakov, J. Vassileva, V. Hadjidekov, Cutting down the radiation dose on CT urography: how it is done and what results are received?, **Radiation Protection Dosimetry**, Volume 165, Issue 1-4, July 2015, Pages 172–174.
9. Yumi Yanaga, Kazuo Awai, Yoshinori Funama, Takeshi Nakaura, Toshinori Hirai, Sebastien Roux3 Yasuyuki Yamashita1 Low dose MDCT Urography: feasibility study of low tube voltage technique and adaptive noise reduction filterAJR.2008 Aug,.171:508-12.
10. Ravichandran, Adityan&Senthamil, Selvan&Karthiga, S &Prabhu, CS &Padhmini, B. (2021). Triphasic Single Bolus and Biphasic Split Bolus Techniques in Computed Tomography Urography: A Pilot Study. SBV Journal of Basic, Clinical and Applied Health Science. 4. 2-9. 10.5005/jp-journals-10082-02275.
11. Li jenwang ,Yon-cheong wong,Yi-Shuanhwang,Ying-Hsu Changsplit bolus CTU achieve more than half of radiation dose reduction in female and overweight patients than conventional single bolus computed urography translational oncology,vol14 issue8 august 2021.