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A Study on Evaluation of Dose and Image Quality by Computed Tomography Scan Machine (CT)

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Abstract:
The aim of this study is to conduct information on common CT examinations using computed tomography, specifically focusing on the radiation dose associated with non-contrast spiral abdomen pelvis CT examinations. Furthermore, is to develop a new low dose protocol and assess the dose and image quality of this protocol.
Data was collected from 16 consecutive patients who underwent non-contrast abdomen-pelvis CT examinations in radiology department. The study aimed to recorded specific parameters such as patient information, machine factors, and CT dose index volume (CTDIvol) and dose length product (DLP) by applying two types of protocols. 16 patients were examined with standard protocol and low-dose protocol. The results for the standard protocol and the proposal low dose protocol showed that patient's dose decreased by 50 %. For the 200 mAs protocol, the median value of CTDI vol was 12.94 mGy, and its range was from 12.88 mGy to 12.93 mGy. The median value of the dose length product was 571.48 mGy-cm, and its range was from 356 mGy-cm to 372 mGy-cm. The effective dose range was from 7.8 to 8.1 mSv according to the ICRP100, and according to the ICRP60, the range was from 6.9 to 9.4 mSv. For the 30 mAs protocol, the value of CTDI vol was 1.7 mGy, the median value of DLP was 571.48 mGy-cm, and its range was from 73.7 mGy-cm to 99.8 mGy-cm. The effective dose range was from 1.04 to 1.41 mSv, according to $ICRP_{100}$. According to ICRP60, the range was from 1.19 to 1.61mSv. Results showed a significant improvement in image quality with a 50% reduced contrast-enhanced abdomen CT scans, allowing for equivalent disease detection capacity.No survey was done as this study was based on date collected and permission took from patient and department doctor as this study is mainly radiological and aims for improvement of image and quality and to check the doses

Keywords: *non-contrast spiral abdomen, low dose protocol, image control, CT, standard dose protocol.*

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I. Introduction

CT, or computed tomography, is a specialized imaging machine in diagnostic radiology that plays a important role [1,2]. It utilizes x-ray technology to create detailed pictures of the inside of the body in two dimensions, three dimensions, and volumetrically [3,4]. By assessing the x-ray attenuation properties of the human body, CT can detect abnormalities such as cancer, trauma, emphysema, pulmonary embolism, and brain infarction [5,6]. The first CT scanner was invented by Godfrey Hounsfield in England in 1972 [5,7]. The introduction of helical CT took place in the 1990s [5,8], followed by the production of dual-slice systems in 1994 and multi-slice systems in 1998 [9,10]. The use of CT has experienced a significant rise in recent years, with approximately 70 million CT examinations performed annually in the United States [7,11]. Concerns regarding the radiation associated with CT scans emerged in the 2000s, initially focusing on pediatric CT examinations. This raised concerns about potential carcinogenic effects from medical imaging [12,13]. In a study conducted in 2009, it was estimated that around 29,000 future cancer cases in the United States could be linked to CT examinations conducted in 2007, representing approximately 2% of the country's annual cancer cases [12]. The contribution of CT to medical exposure in the United Kingdom increased from 20% in 1990 to 40% in 1999 [13]. It is believed that around 0.2% of incident cancers in the United Kingdom may be attributed to CT examinations [14,15]. As a response to these concerns, the United States Food and Drug Administration and the Joint Commission have published position papers and initiated efforts to reduce medical radiation doses [16]. The European Commission (EC) has proposed the implementation of CT dose guidance levels for examinations as part of policies aimed at reducing radiation doses[17,18]. The commonly used term to describe CT dose is the CT dose index (CTDI), which represents the dose profile resulting from a single slice[5,19]. Another unit used is the Dose Length Product (DLP), which quantifies the total volume of the patient or phantom irradiated during one examination [5,20]. Unenhanced abdomen pelvic CT scans were initially suggested for assessing urinary tract pain [21,22]. These scans are used to evaluate the presence, size, and position of obstructive stones. In Dr. Soliman Fakeeh Hospital in Jeddah, Saudi Arabia, the most frequently performed CT examinations involve non-contrast spiral scans of the abdomen and pelvis for patients with flank pain and for follow-up after extracorporeal shock wave lithotripsy (ESWL). The non-contrast abdomen pelvic CT scans are performed on approximately 3,000 patients annually, with that number reaching 4,000 patients in 2015, in addition to other types of examinations totaling 2,500 patients.

The purpose of this paper was a survey for common computed tomography CT examination, assess radiation dose associated with non-contrast spiral abdomen pelvis CT examination, to find a way to implement a new low dose protocol and to evaluate dose and image quality for such low dose protocol.

II. Materials And Methods

CT scanner: For this study a Multi-slice CT scanner was used (Brilliance, Philips medical, Eindhoven, the Netherlands, (Figure 1). The CT has been located in Dr. Soliman Fakeeh hospital, Jeddah, KSA

Figure (1) CT- Philips's brilliance 64 slices

Dosimetry tools

The equipment was used for measuring the CTDI: CT ionization chamber and electrometer calibrated for CT beam qualities. Ionization chamber RaySafe X_2 CT sensor (Ion chamber) made in Sweden, **(Figure 2)**

Figure (2) Ionization chamber and electrometer

Figure (2) Electrometer, ionization chamber for CT scan, and Polymethyl methacrylate (PMMA) phantom with a head (16 cm diameter) and a body (32 cm diameter) were used for measuring the CTDI 100 central and peripheral, **(Figure 3).**

Figure (3) PMMA CTDI phantom

CT examination

The most popular kinds of CT examinations were chosen by gathering data from the available Picture Archiving and Communications Systems (PACS) for the non-contrast abdomen-pelvis CT exams performed on 16 consecutive patients in our radiology department. Reporting methods were also employed to comprehend the clinical rationale for the sequencing of the investigations. The period of data collecting was from 2018 to 2019. Evaluating acute flank pain and monitoring the patient following extracorporeal shock wave Lithotripsy (ESWL) were the goals. The existence of renal or ureteral calculi, perinephric or periureteral stranding, pelvically ectasis, its degree, and any other pertinent radiological results were carefully investigated in each CT scan. The machine's dosage information was used to record specific parameters for the non-contrast abdomen and pelvis spiral protocol, such as the dose length product (DLP) and CT dose index volume (CTDIvol). The participants also had to record information on additional particular examination-related factors. (1) Patient information [weight, sex, length, body mass index (BMI)] (2) Machine factors of the machine protocol [tube current (mA), tube kilovoltage peak (kVp), pitch, cycle time], and milliamperes per second (mAs)]. The DLP was recorded from the CT dose information. The local protocol was studied. In this protocol, the kVp120 fixed and tube current mAs variable per patient scan, **(Table 1).**

Effective dose (E) = DLP . K…..………………..……..equation (1)

Where: K coefficient is specific only to the anatomic region scanned.

To calculate the effective dose for all patients, Equation (1) will be utilized. The effective dose (E) is obtained by multiplying the dose length product by the tissue radiation weighting factor (K). In this case, the K values derived from ICRP60 for the multi-slice CT scanning parameters site protocol **[Table 1].** Standard abdomen-pelvis region at 120 kilovolts peak (kVp) were approximately 0.0161. The dose data collected was entered manually into the SPSS program, which was then used for data analysis. Using SPSS (IBM-V:26), further calculations and statistical analysis can be performed to analyze the collected data.

III. Results And Discussion

Survey for common CT examination

According to a survey on common CT examinations, there were 15557 CT examinations performed over the course of two years (table 2), with ≈80% of those exams being non-contrast abdomen and pelvis. Every year, the number of non-contrast spiral CT (NCCT) scans has increased **(Figure 4).**

With an average of 618 patients each month and a total of 7415 patients per year, the NCCT number in 2019 ranged from 443 to 923 patients per month. The NCCT number ranged from 455 to 983 people per month in 2020, with an average of 678 patients per month and an annual total of 8142 patients. In 2019, the number of patients undergoing non-contrast CT examinations grew from 3297 to 3723 annually. Additionally, in 2020, other exams went from 4118 to 4619.

Dose for No-contrast CT abdomen pelvis

16 patients were included in this investigation, who were divided into two groups based on BMI, Table **(3).** The range of the patient's body mass index (BMI), with an average of 29.5 kg/m, was 13.4 to 51.42. Patient dosage information (one scan phase per patient): the median mAs used ranged from 34 mAs to 334 mAs, the median CTDI vol value was 12.07, and the median dose length product was 586.45 mGy-cm, with a range of 83.30 mGy to cm to 1179.70 mGy-cm. The International Commission of Radiological Protection (ICRP) 103 states that the effective dosage range was 1.1 to 16.5 mSv, with an average of 8.22 mSv and according to the $ICRP_{60}$ the range was 1.3 to 18.93mSv with average 9.38mSv.

For suspected renal discomfort, a total of 16 patients had two to four non-contrast CT exams. A patient's median number of annual CT scans was 2 (minimum 1 scan and maximum 4 scans). The two groups shared the effective dosages, which ranged from 3.98 to 16.5 mSv, according to $ICRP_{100}$ For BMI ≤30 kg/m^2, the effective dose in group one was 11.5 mSv; for BMI ≥30 kg/m^2, it was 16.5 mSv **(table 4).**

The two groups shared effective doses ranging from 4.5 to 18.93 mSv, as per the ICRP60. Only BMI ≤30 kg/m^2 received the effective dosage of 13.2 mSv in group four; for BMI ≥30 kg/m^2, the effective dose was 18.93 mSv **(Table 2).** While the effective dose differed for individuals with the same BMI, there was a strong relationship between the effective dose and BMI. As the mAs grew, the effective dose also increased. Significant differences were seen in the effective dose, effective mAs, and BMI, all of which varied significantly ($p < 0.01$). The effective dose had a modest connection ($r = 0.53$) with BMI and a significant correlation ($r = 0.94$) with mAs. A substantially significant difference (p<0.01) was observed in the $CTDI_{vol}$. DLP demonstrated the highly significant difference (P<0.01) and highly correlation (r =0.94) with $CTDI_{vol}$.

Comparison between Standard and low dose protocol

Both the normal technique and the low dose protocol were used to investigate 16 patients. The outcome for both the regular protocol and the low dose protocol suggestion demonstrated that patients' dose decisions varied by 60 %. The CTDI vol for the 200 mAs protocol ranged from 12.88 mGy to 12.93 mGy, with a median value of 12.94 mGy. The effective dosage range was 7.8 to 8.1 mSv according to the ICRP100 and 6.9 to 9.4 mSv according to the ICRP60. The median value of the dose length product was 571.48 mGy-cm, with a range of 356 mGy-cm to 372 mGy-cm.

According to the ICRP100 **Table (4),** the CTDI vol value for the 30 mAs protocol was 1.7 mGy, the DLP median value was 571.48 mGy-cm with a range of 73.7 mGy-cm to 99.8 mGy-cm, and the effective dose range was 1.04 to 1.41 mSv. The range was 1.19 to 1.61 mSv, according to ICRP60 **(Table 5).**

Two investigations on the pelvic region show image artifact **(Figures 5, 6 and 7).** In one inspection, patient motion artifact was evident (figure 7 C and D). For right kidney tissue, the ROI's median heart rate (HU) was 26.2 at 200 mAs and 28.6 at 30 mAs. For left renal tissue, the ROI median HU was 26.8 HU at 200 mAs and 28.4 HU at 30 mAs. The right kidney's (ROI) HU standard deviation increased from 14.3 HU to 40.6 HU, and there was no significant difference ($p < 0.05$) between the two procedures' results.

The (ROI) HU standard deviation (SD) of right kidney tissue change in two protocols was significant difference ($p > 0.05$). The (ROI) median HU for Urinary bladder was 12.3HU at 200mAs and it was 10.8HU at 30mAs and the (ROI) HU change between two protocol was significant difference ($p <0.05$). The (ROI) median HU standard deviation of Urinary bladder was increased from 18.7HU at 200mAs to 49.5HU at 30mAs for right kidney. The (ROI) HU standard deviation (SD) of urinary bladder change in two protocols was a significant difference ($p >0.05$).

In **Figure 6**, the ring artifact was masked the left pelvic ureter stone <3mm at 30mAs. Figure was showed the urinary bladder thick wall with calcification in two protocols.

Figure 8 showed an aortic aneurysm with aortic wall calcification in the two protocols. Images (A & B) display an aortic aneurism with wall calcification, a right kidney stone less than 2 mm, and a right ureteropelvic junction stone larger than 2 mm. Images C and D display the duple J ureteric stent's distal end at the bladder.

Figure 9, The BMI of the patient was 29.6 kg/cm^2. 4mm axial non-contrast CT scans: (A, C) scanned at 200mAs using a conventional dosage and an ED of 8.09mSv; (B, D) scanned at 30mAs using a low dose and an ED of 1.21mSv. A&B scans show a right kidney ectopic to the left kidney with a stone larger than 2 mm. There is a D ring artifact. In **Figure 10**,A patient had BMI of 20.2 kg/cm^2. He underwent 4mm axial non-contrast CT scans, with (A) standard-dose scanning at 200 mAs and an ED of 8.09 mSv, and (B) low-dose scanning at 30 mAs and an ED of 1.21 mSv. Upper end duple J in the left kidney is seen in A&B. In **Figure 11**, the BMI of a 49-year-old man was 32.7 kg/cm^2. 4mm axial non-contrast CT scans, for which (A) were scanned at 200 mAs using a standard dosage and (B) at 30 mAs using a low dose and an ED of 1.20 mSv. >2 mm urinary bladder stone is seen in A&B. In **Figure 12**, A female 55-year-old's BMI was 42.9 kg/cm^2. A, C, and E underwent standard-dose scanning at 200 mAs with an ED of 9.46 mSv on 4mm axial non-contrast CT images, while B, D, and F underwent low-dose scanning at 30 mAs with an ED of 1.42 mSv. Right kidney back pressure is seen in A&B pictures. Rough ureteric stone >2 mm is seen on C&D. Image (F) displays a ring artifact.

In figure 13, a 48-year-old man with an BMI of 28.4 kg/cm^2 underwent 4mm axial non-contrast CT scans; (A) were scanned at 200 mAs with an ED of 8.28 mSv, and (B) at 30 mAs with an ED of 1.24 mSv. Both ureters are dilated in A&B imaging, and a ring artifact partially masks a left pelvic ureter stone at 30 mAs in C&D images. In **figure 14**, a 45-year-old male patient received 4mm axial non-contrast CT scans with an BMI of 23.3 kg/cm^2, scanned at 200 mAs with an ED of 8.66 mSv in (A) and 30 mAs with an ED of 1.3 mSv in (B). B displays the left pelvic ureter stone (< 2mm) with ring artifact masking at 30 mAs. In **Figure 15**, in 4mm axial non-contrast CT scans (A, C, E) scanned at 200mAs with an ED of 8.38mSv, and (B, D, F) scanned at 30mAs with an ED of 1.26mSv, ring artifact was observed throughout the entire examination. The 48-year-old male patient's BMI was 31.4 kg/cm^2.

As shown in **Figure (16)**. A male 64-year-old patient got 4mm axial non-contrast CT scans with an BMI of 24.2 kg/cm^2, scanned at 200 mAs with an ED of 8.02 mSv for (A, C), and 30 mAs with an ED of 1.20 mSv for (B, D). Images (A, B, C, D) display a posterior bladder wall that is the focal point of calcification and a diffusely thickened urinary bladder wall. In **Figure 17**, a male

Table (3) Patient number, BMI, mAs, KVP, scan length and dose

17-year-old patient had 4mm axial non-contrast CT scans with an BMI of 32.2 kg/cm^2, where (A, C) were scanned at 200 mAs with an ED of 9.26 mSv and (B, D) at 30 mAs with an ED of 1.39 mSv. Ring artifact is seen in (B, D), and a right distal pelvic uretic stone is seen in (C, D). In **Figure 18**, a 58-year-old male, standard dosage (9.32mSv), BMI 31.4 kg/cm^2. dose-limited (1.4 mSv) (A, B) a localized lesion on the liver, (C, D) exhibit erratic thickening of the bladder wall (soft tissue mass).

Results

Table(1)CTprotocol

ScanningParameters	SiteProtocol
kVp	120
Reconstructionthicknessmm)	4mm
Pitch(mm)	1.172
Collimation(mm)	64x0.625
Gantryrotation(s)	0.75
Matrix	512
Filter	Standard

Table (2) Number of CT examinations 2019 and 2020

	2019	2020
Non contrast examination (abdomen and pelvis) No	3297	3723
Other examination No	4118	4619
Total CT examination No	7415	8142

Survey for common CT examination

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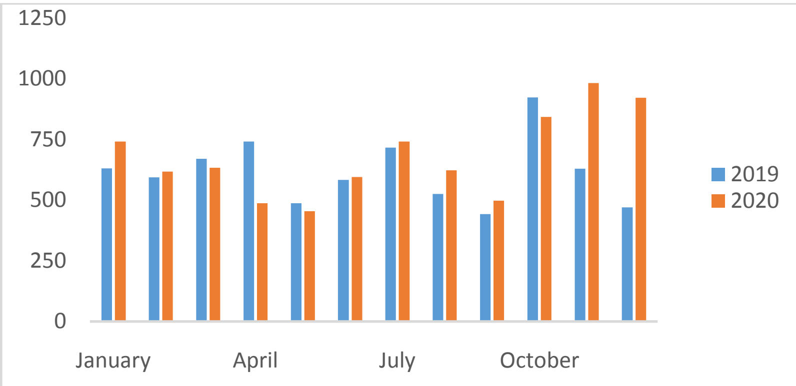


Figure (4) Number of NCCT examination 2019 and 2020

Table (3) Patient number, BMI, mAs, KVP, scan length and dose parameter

	BMI(≤30)	BMI(≥30)
Patient no	8	8
mAs	92-246	100-278
KVP	120	120
CTDI $_{vol}$ (mGy)	(5.9 -15.9)	6.47-23.9

Scan length(mm)	(348 - 603)	356-508
DLP mGy cm	(286 - 824)	354.3-1179.7
E ICRP$_{100}$(mSv)	(3.98 -11.5)	4.8-16.5
E ICRP $_{60}$(mSv)	(4.5 - 13.20)	5.5-18.93

Table(4) Dosesforstandard&lowdoseprotocols

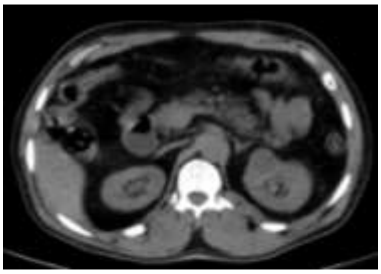
	BMI(≤30)	BMI(≥30)
Patientno	8 (5F and 3M)	8 (4F-4M)
mAs	200 30	200 30
KVP	120	120
CTDI $_{vol}$ (mGy)	(12.88-12.93) *(1.7)	(12.89-12.94) (1.94)
Scan length(mm)	(356-372)	(308-444)
DLP mGy cm	(552-572) *(83-86.3)	(491.3-665.7) (73.7-99.8)
E. ICRP$_{103}$(mSv)	(7.8-8.1) *(1.17-1.21)	(6.9-9.4) (1.04-1.41)
E. ICRP $_{60}$(mSv)	(8.9-9.24) *(1.34-1.39)	(7.91-10.72) (1.19-1.61)

Table (5)CT HU & SD for standard& low dose protocols

	BMI (21.4 – 25.9)	BMI (26.08 -29.7)
Patient no	8(5F and 3M)	8(4F-4M)
mAs	200 (30)	200 (30)
No of image	77-111	77-111
Right Kidney SD	6.2-23 (15.9-38.4)	9.9-21.9 (22.1-50.1)
Left Kidney SD	6.5-23 (23.6-38.4)	16.7-31.9 (23.3-51.2)
Stone SD	(*21**) 3.3-269.9 (24.284.1)	(42*) 97-1455 (25.7-282.4)
Cyst SD	(3*)10.7-13.5 (27.8-334)	(7*)7.5-18 (28.5-45.6)
Bladder SD	9.3-22.9 (22.1-74.8)	11.8-109 (29.3-90.2)
Artifact	2	


(A)


(B)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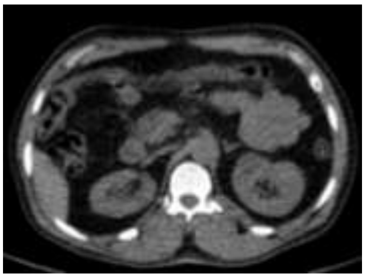
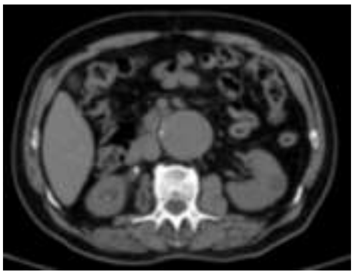
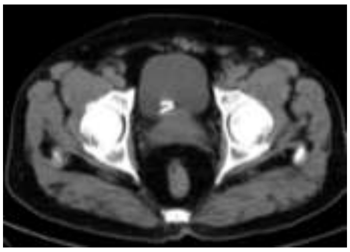

(D)

Figure (7) A 57-year-old Male had BMI 27.9 kg/cm^2. 4mm axial non-contrast CT images, for (A,C) scanned by standard-dose at 200mAs, with ED 7.94 mSv and (B, D) scanned by low-dose CT at 30mAs, with ED 1.19 mSv. (A & B) images show right kidney stone>2mm, (C,D) images show left kidney cyst, and upper abdomen motion artifact.


(A)


(B)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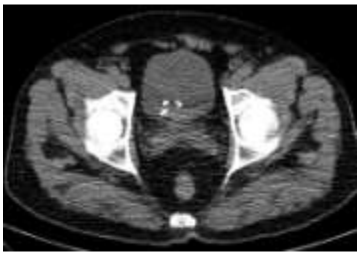
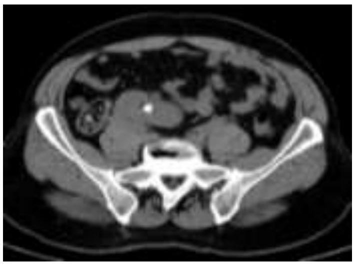
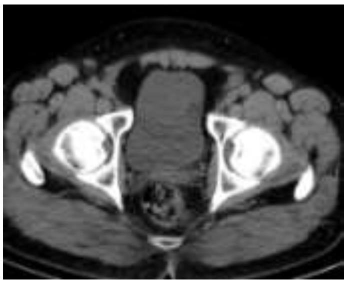

(D)

Figure (8) A 67-year-old male had BMI = 26 kg/cm^2, 4mm axial non-contrast CT images, for (A&C) scanned by standard-dose at 200mAs with ED 7.80mSv, and (B&D) scanned by low-dose at 30mAs, with ED 1.17mSv. (A & B) images show right kidney stone <2mm, right ureteropelvic junction stone > 2mm and aortic aneurism with wall calcification. C & D images show distal end of duple J ureteric stent at the Bladder



(A)

(B)



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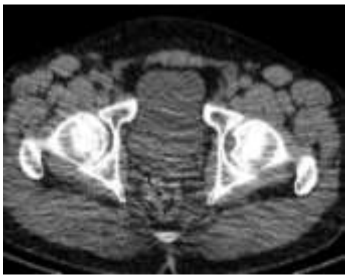
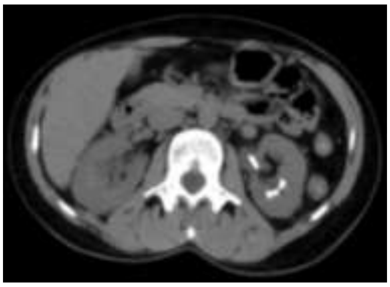


(D)

Figure (9) A 52-year-old, male had BMI 29.6 kg/cm$^{2.}$ 4mm axial non-contrast CT images, for (A, C) scanned by standard-dose at 200mAs with ED 8.09mSv, and (B, D) scanned by low-dose at 30mAs with ED 1.21mSv. A&B images demonstrate left kidney ectopic right kidney with stone> 2mm. D ring artifact appears.



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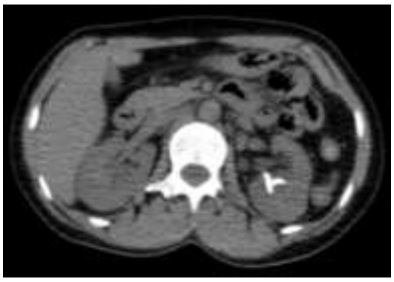
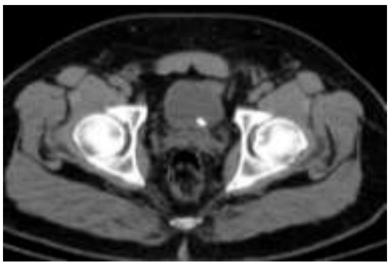


(B)

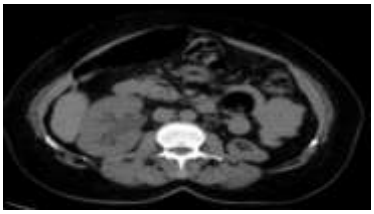
Figure (10)A 32 -year-old, male had BMI 20.2 kg/cm^2. 4mm axial non-contrast CT images, for (A) scanned by standard-dose at 200mAs with ED 8.09mSv, and (B) scanned by low-dose at 30mAs with ED 1.21mSv. A&B show upper end duple J in left kidney.



(A)

(B)

Figure (11) A 49-year-old, male had BMI= 32.7 kg/cm^2. 4mm axial non-contrast CT images, for (A) scanned by standard-dose at 200mAswith ED 7.99mSv, and (B) scanned by low-dose at 30mAs with ED 1.20mSv. A&B show urinary bladder stone>2mm.



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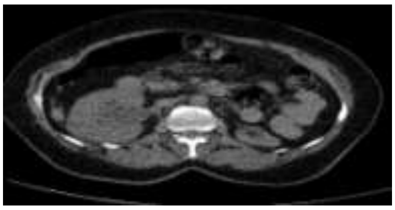

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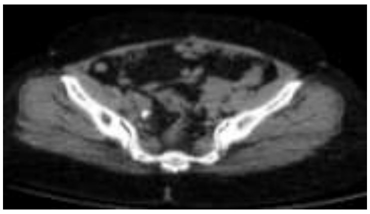

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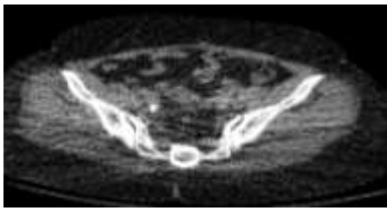

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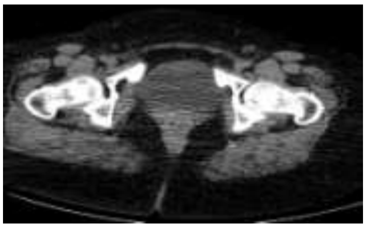
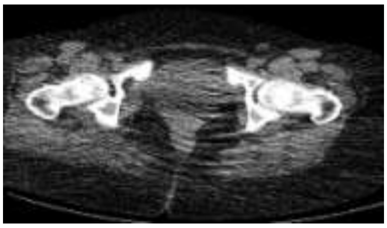
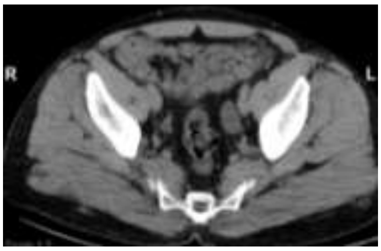


(E)

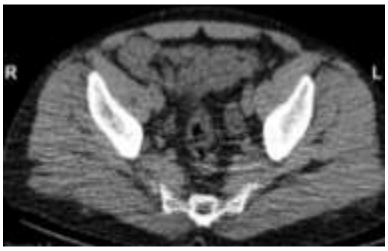


(F)

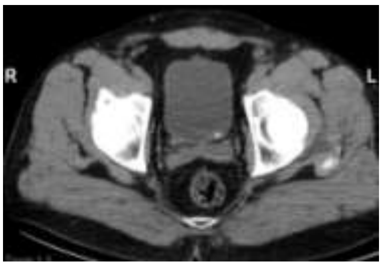
Figure (12) A 55 -year-old female, had BMI= 42.9 kg/cm^2. 4mm axial non-contrast CT images, for (A, C, E) scanned by standard–dose at 200mAs with ED 9.46mSv, and (B, D, F) scanned by low-dose at 30mAs with ED 1.42 mSv). A&B images show right kidney back pressure .C&D show right ureteric stone>2mm. (F) image show ring artifact appears.



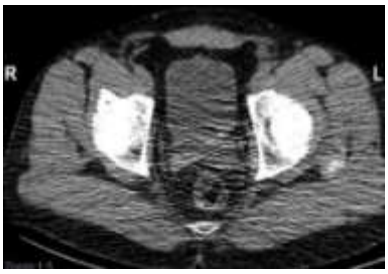
(A)



(B)

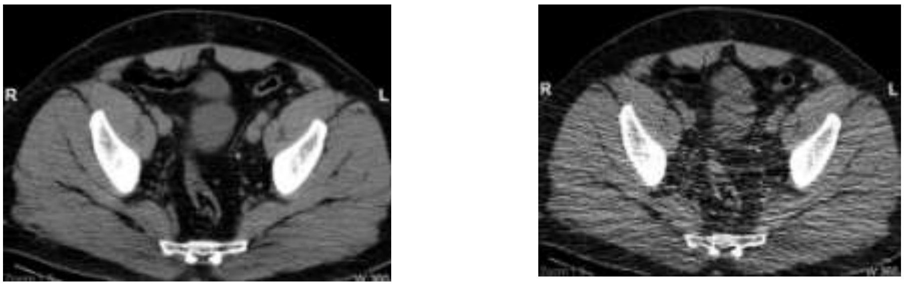


(C)



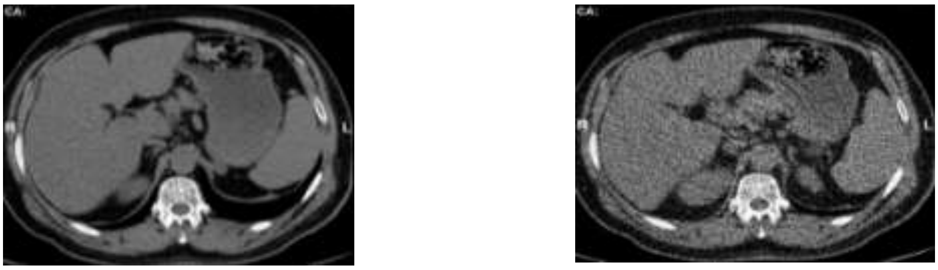
(D)

Figure (13) a 48 -year-old, male had BMI 28.4 kg/cm^2. 4mm axial non-contrast CT images, for (A) scanned by 200mAs with ED 8.28mSv, (B) scanned by 30mAs with ED1.24mSv. A&B images show dilated both ureters, and C&D images show ring artifact which partial masked left pelvic ureter stone at 30mAs.

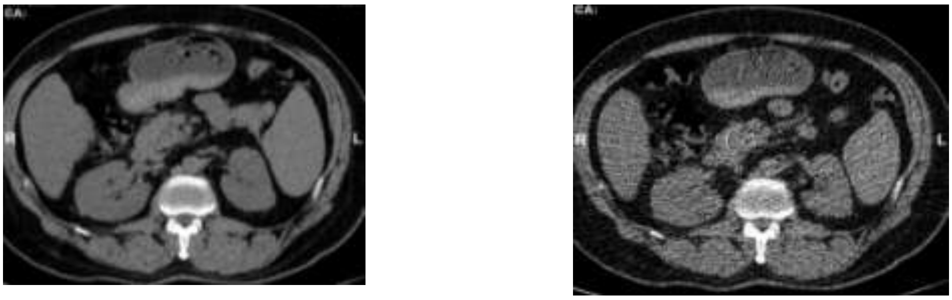


(A) (B)

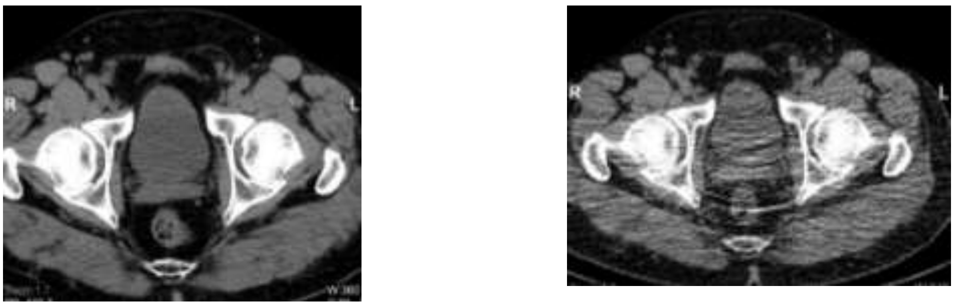
Figure (14) A 45 -year-old, Male had MBI= 23.3 kg/cm^2, 4mm axial non-contrast CT images, for (A) scanned by 200mAs with ED 8.66mSv, and (B) scanned by low-dose at 30mAs with ED1.3mSv. B show the ring artifact masked left pelvic ureter stone (< 2mm) at 30mAs.



(A) (B)

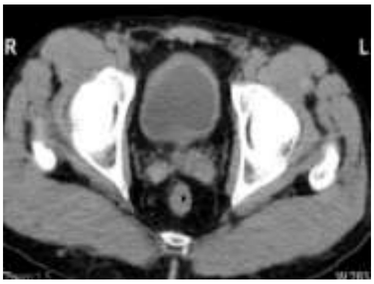


(C) (D)

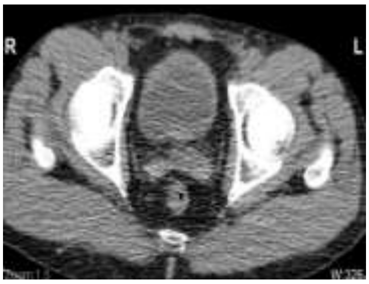


(E) (F)

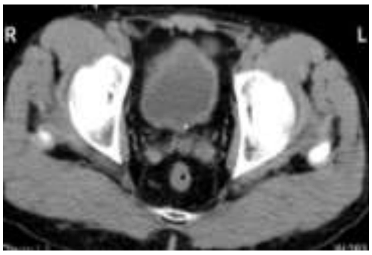
Figure (15)A 48 -year-old male had BMI 31.4 kg/cm^2, 4mm axial non-contrast CT images, for (A, C, E) scanned by 200mAs with ED 8.38mSv, and (B, D, F) scanned by 30mAs with ED1.26mSv, at 30mAs ring artifact appears in the whole the examination.



(A)



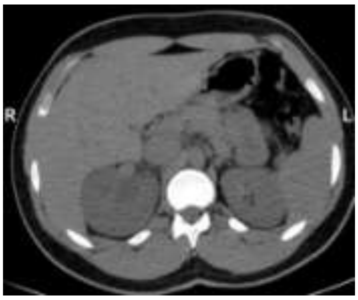
(B)



(C)

(D)

Figure (16) A 64 -year-old, male had BMI= 24.2 kg/cm^2, 4mm axial non-contrast CT images, for (A, C) scanned by 200mAs with ED 8.02mSv, and (B, D) scanned by 30mAs with ED 1.20mSv. (A, B, C, D) images show diffuse thickened urinary bladder wall with calcification focus at the posterior bladder wall.



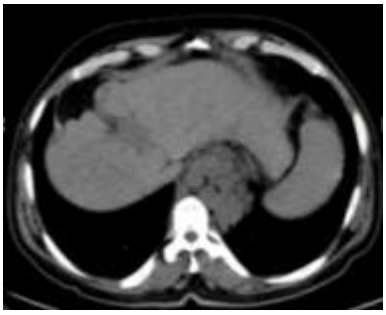
(A)

(B)

(C)

(D)

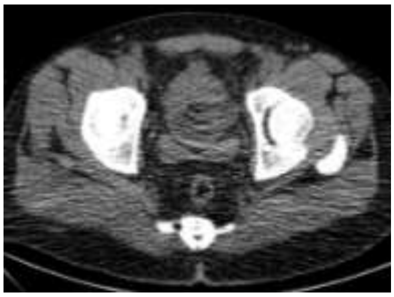
Figure (17)A 17 -year-old, male had BMI 32.2 kg/cm^2, 4mm axial non-contrast CT images, for (A, C) scanned by 200mAs with ED 9.26mSv, and (B, D) scanned by 30mAs with ED 1.39mSv. (B, D) show ring artifact, (C, D) show right distal pelvic uretic stone.



(A)

(B)

(C)



(D)

Figure (18) Male 58-year-old, BMI 31.4 kg/cm^2, standard dose (9.32mSv) low dose (1.4mSv) (A, B) show Liver focal lesion, (C, D) show irregular bladder wall thickening (soft tissue mass)

IV. Conclusions

In terms of HU, the low dosage proposal procedure did not differ much from standard one, and as noise levels rose, there was also no discernible change in terms of stone detection sensitivity. There was a noticeable rise in loudness for the bladder. Therefore, it is acceptable to use a low dose to identify urinary calculi in campers to stander one without lowering the sensitivity to identify stones. The non-contrast abdominal pelvis low dose was useful in identifying additional findings such as renal abnormalities, bladder mass, thick wall, and focal lesion in the liver.

In conclusion, results considerably boosted the image quality of 50% decrease LD contrast-enhanced abdomen CT scans, with equivalent detection capacity with routine-dose scans and both diagnostically acceptable image quality that may be employed in diagnosis of disease.

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