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# Optimal Computed Tomography Protocol to Reduce the Effective Radiation Dose for Obese Patients

***Hayder A. Aljweber[1], Eslam Mamoun[2], Ahmed Elgarayhi[1], Mohammed Sallah[1]***

*[1] Physics Department, Faculty of Science, Mansoura University, Mansoura 35516, Egypt*

*[2] Radiation Safety Office, University of Pittsburgh, Pittsburgh, PA 15260, USA*

*E-mail: hayderbdn81@gmail.com*

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**Abstract:**The main aim of this work is to reduce the effective radiation dose for obese patients by using relevant physical techniques.Two CT protocols (A: n=50, 120KV/190-60 mAs, and B: n=50, 100 KV/190-60 mAs) were used on 100 patients. Following a referral to an abdominal CT scan with contrast for the two groups (A and B), dosage estimations were made for each group.

The following results were obtained : Computed Tomography Dose Index ( CTDI) (A: 12.5 mGy; B: 7.11 mGy, p-value < 0.05), Dose Length Product (DLP) (A: 516.11 mGy.cm; B: 258.6 mGy.cm, p-value < 0.05) and the Effective Dose (ED) (A: 7.73 mSv; B: 3.87 mSv, p-value < 0.05).

In the suggested regimen for the overweight and obese individuals, lowering the tube voltage from 120 kV to 100 kV enables a significant reduction in radiation dose without suffering a sizable loss in diagnostic image quality.

***Keywords****:* Computed Tomography, Image Quality, Effective dose, Abdomen CT scan; Body mass index BMI.

## Introdction

We have always been concerned about how much radiation our patients are exposed to during various imaging procedures because we are all aware that CT is a high dose test. The effective dose, or the radiation received by vital organs, is how CT dose is calculated. The narrow volume of tissue (1–10 mm) exposed to the primary beam receives the majority of the dose during a CT scan. Outside of this, scatter radiation will also cause some dosage to tissues. The radiation exposure from CT scans varies from patient to patient. The size of the body part being imaged, the treatment being performed, the type of CT equipment used, and how it is being used will all affect the radiation dose [1].

Since the CT scan was created, efforts have been made to decrease the radiation exposure by altering elements like tube current, tube potential, scan length, and rotation time, as well as by increasing pitch and beam collimation. This study looked at how different scanning procedures affected the radiation exposure for obese individuals undergoing abdominal surgery. According to one study, the CT scan is mostly responsible for the radiation exposure from imaging treatments [2]. The resulting radiation dose can exceed tens of mSv due to the demand for thin slices with adequate image quality, particularly for post-processing activities [3].

Patients who are obese are likely to have significantly higher readings because they often need a greater effective dose to keep their images consistent. Due to greater X-ray beam attenuation, abdominal CT scanning is difficult in obese patients [4]. Given the risks of radiation exposure, broad adoption of standard scan parameters has been questioned [5].

Due to the availability of and use of automatic tube current modulation (ATCM) in clinical practice, and the documented linear relationship between noise, tube current (mA) manipulation has been the focus of radiation dose optimization strategies from both CT users and manufacturers. When obese individuals undergo routine abdominal venous phase CT scans, low kV hasn't been employed commonly [6,7].

To ensure that image quality is maintained, tube potential modifications are made based on the size of the patient and the test form, as well as the appropriate customization of the relevant scanning parameters [8]. When filtered back projection (FBP) is employed to reconstruct the image, radiation dose reduction measures such decreased tube current or voltage, enhanced quantum noise, and streak artefacts drastically diminish image quality [9,10]. People who are overweight experience these fears more intensely. As a result, additional noise reduction filters, including iterative reconstruction (IR), are advantageous for scans with low radiation dosage [9].

As the use of CT scans grows in many nations, they have become a significant source of medical radiation exposure globally. The quantity suggested by the International Commission on Radiological Protection (ICRP) for radiation protection reasons is known as the effective dose (ED), and it has been used to compare the radiation risk from various clinical diagnostic protocols and modalities. Because the ED is based on organ doses that are not always available, it is usual practice to estimate radiation doses during CT testing using the dose length product (DLP) or volume CT dose index (CTDIvol) from the CT scanner console. The relative radiation intensity is measured using the CTDIvol unit, which is not a reliable indicator of doses to patient organs. By dividing the CT scan length by the CTDI volume, the DLP is produced. DLP can be compounded by conversion factors to produce an estimate of the total radiation dose received during a CT scan [11,12].

Obese people usually require a higher effective dose to maintain image quality. Due to the decreased SNR and elevated X-ray beam attenuation, obese patients have trouble undergoing abdominal CT scanning.

Obese patients receiving routine abdominal venous phase CT scans have not typically used low kV [13,14]. Tube potential changes are done to maintain picture quality based on the size of the patient, the type of examination, and the appropriate customization of related scanning factors. To reduce the generation of scattered radiation, the thickness of the patient should be compressed. The thickness of the irradiated area causes a reduction in the scattered radiation. In addition, one of the key studies in this area found that it was difficult to detect corpse stuffers in emergency rooms. Plain radiographs are not very useful in the majority of suspects because to the small size of baggies. Contrarily, a CT scan of the abdomen is expensive and exposes the patient to a lot of radiation. In that study, the accuracy, radiation dose, and image quality of low-dose CT scans were compared to those of standard doses.

The best method of screening for body stuffers appears to be a low dosage CT scan when the baggies are larger than one centimeter. However, a standard dosage CT scan will be more beneficial in the context of significant clinical symptoms because to superior image quality, particularly in suspected ruptured baggies [15]. Additionally, from research comparing the diagnostic performance of a linearly blended 120 kV protocol and a reduced-dose 100 kV CT protocol with sophisticated modelled iterative reconstruction for the evaluation of acute, non-traumatic abdominal pain.

Reduced-dose abdominal CT at 100 kV produces great image quality and high diagnostic accuracy in the evaluation of acute non-traumatic abdominal pain [16]. Furthermore, investigations comparing the image quality produced by low-dose computed tomography (LDCT) on obese persons with urolithiasis using various reconstruction approaches. Iterative reconstruction techniques make it possible for obese patients with a BMI between 25 and 35 kg/m2 to undergo LDCT for urolithiasis. The recommended algorithm in terms of image quality is IMR, which could reduce the requirement for additional testing as a result of previously measured non-diagnostic scans [17]. Investigations have also been carried out to evaluate the Iterative Dose Reduction approach (IDREAM) as an iterative reconstruction approach. The investigation's findings supported IDREAM's viability as an iterative reconstruction algorithm [18].

Additionally, from research to detail the first time ULDCT was used in the emergency room to assess acute abdominal pathology. Due to its high clinical yield and comparable radiation exposure, ULDCT seems to be a promising alternative to abdominal radiography for the diagnosis of specific acute abdominal diseases in the emergency room [19]. Additionally, the effects of minimal radiation exposure in abdominal computed tomography (CT) when paired with noise reduction filters are being studied to see if this method might avoid the issues associated with scanning obese patients. For larger patients having abdominal CT, the relatively low tube voltage method with the use of iterative reconstruction is possible and advantageous, particularly in terms of radiation dose reduction. The results of that investigation demonstrated a substantial radiation dose reduction for abdominal CT done at 100 kV. Iterative reconstruction dramatically increased the SNR and noise level. As a result, utilizing high-dose procedures with filtered back projection has significant disadvantages compared to using the low-dose strategy with iterative reconstruction. The diagnostic utility of the low-kV approach with iterative reconstruction in evaluating obese patients having abdominal CT should be investigated further [20].

In this study, we evaluated the CT suggested protocol for overweight patients (about 90 –140 kg weight range) and contrasted it with the conventional protocol for the abdomen region, using modulation dosage (voltage reduction from 120 kV to 100 kV, and auto mA). The goal is to significantly reduce the radiation dose without significantly reducing the diagnostic image's quality.

## 2. Materials and Analysis Technique

### 2.1. Study Patients

A contrast-enhanced abdomen CT scan was advised for 100 patients with BMIs between 28 and 45 kg/m2. The selected patients underwent two CT acquisition methods (A: n = 50, 120KV/190-60 mA, and B: n = 50, 100 KV/190-60 mAs), and image quality was evaluated for the A and B groups (B: n=50, 100 KV/190-60 mAs, PP).

### 2.2. Calculations of Radiation Dose

While the patient dose calculations (CTDIvol and DLP) for the A and B groups were extracted from summary dose reports, the effective dose was estimated using 0.015 as a conversion factor [21]. Using the following equations

$$CTDI_{vol} = CTDI_{w} / Pitch \qquad (1)$$

where CTDIw is a description that is created by averaging the center and periphery CTDIvol scores.

$$DLP = CTDI_{vol} \times \text{length of scan (in mGy.cm)} \qquad (2)$$

$$\text{effective dose (ED)} = \text{DLP} \times 0.015 \text{ (mSv)} \qquad (3)$$

Statistics were used to compare the dosage estimations ($CTDI_{vol}$ and DLP for groups A and B. Both groups' results for all patient dose metrics were statistically compared, and the gathered information was examined in Microsoft Office Excel (version 19). See Appendices I, II and III.

## Results and Discussion

This section displays the dosage calculation parameters (DCP) for groups A and B. Group A (the standard protocol), as seen in figures 1, 2, and 3 has more DCP than group B (the proposed protocol), which has less parameters (see Table (1)). With a p-value of 0.05, it is clear that the patient dosage estimations (CTDIvol, DLP, and effective dose) for group B were considerably lower than those for group A.

**Table (1):** *CTDIvol*, *DLP*, and Effective dose of group ***A*** versus ***B***

| Group | *CTDIvol* (mGy) | *DLP* (mGy.cm) | Effective dose (mSv) |
|---|---|---|---|
| Group ***A*** (standard protocol) | 12.5 | 516.11 | 7.73 |
| Group ***B*** (proposed protocol) | 7.11 | 258.6 | 3.87 |

Note that in this proposed protocol, we obtained these good results, which reduced the effective radiation dose to almost half compared to the standard protocol, which did not affect the quality of the diagnostic image, as shown in Figure 4.

**Appendix I.**

**Table (I.1):** Dose report (CTDI, DLP, ED) values for the standard protocol and the proposed protocol

| Patient | CTDI 100 | CTDI 120 | DLP 100 | DLP 120 | ED 100 | ED 120 |
|---|---|---|---|---|---|---|
| P01 | 2.58 | 8.61 | 214 | 470.6 | 3.21 | 7.05 |
| P02 | 8.28 | 12.09 | 198.5 | 521.3 | 2.97 | 7.81 |
| P03 | 9.44 | 12.18 | 268.5 | 588 | 4.02 | 8.82 |
| P04 | 6.6 | 15.99 | 380.2 | 583.3 | 5.7 | 8.74 |
| P05 | 8.4 | 9.8 | 279.1 | 478.1 | 4.18 | 7.17 |
| P06 | 8.23 | 16.7 | 260.4 | 485.7 | 3.9 | 7.28 |
| P07 | 6.8 | 14.08 | 188.9 | 561.1 | 2.83 | 8.41 |
| P08 | 3.73 | 14.51 | 133.9 | 459.3 | 2 | 6.88 |
| P09 | 7.08 | 14.37 | 246.5 | 804.8 | 3.69 | 12.07 |
| P10 | 8.71 | 10.28 | 317.1 | 325.2 | 4.75 | 4.87 |
| P11 | 7.39 | 14.84 | 251.4 | 583 | 3.77 | 8.74 |
| P12 | 8.28 | 11.99 | 248.9 | 379.5 | 3.73 | 5.67 |
| P13 | 3 | 10.09 | 102 | 431.8 | 1.53 | 6.47 |
| P14 | 7.58 | 10.78 | 214 | 354 | 3.21 | 5.31 |
| P15 | 9.44 | 6.12 | 268.5 | 177 | 4.02 | 2.65 |
| P16 | 6.6 | 11.87 | 380.2 | 683 | 5.7 | 10.24 |
| P17 | 7.39 | 8.48 | 263.2 | 290 | 3.94 | 4.35 |
| P18 | 2.22 | 12.81 | 71.3 | 462 | 1.06 | 6.93 |
| P19 | 8.4 | 9.79 | 279.1 | 318 | 4.18 | 4.77 |
| P20 | 8.23 | 12.65 | 260.4 | 909.5 | 3.9 | 13.64 |
| P21 | 6.8 | 11.36 | 188.9 | 433.6 | 2.83 | 6.5 |
| P22 | 3.73 | 10.56 | 133.9 | 624 | 2 | 9.36 |
| P23 | 1.25 | 12.94 | 24.8 | 447.9 | 0.37 | 6.71 |
| P24 | 9.69 | 13.38 | 373.8 | 363 | 5.6 | 5.44 |
| P25 | 7.08 | 10.99 | 246.5 | 347.8 | 3.69 | 5.21 |
| P26 | 7.98 | 15.18 | 385 | 637.6 | 5.77 | 9.56 |
| P27 | 8.71 | 16.64 | 317.1 | 961.3 | 4.75 | 14.41 |
| P28 | 7.92 | 8.61 | 252.4 | 470.6 | 3.78 | 7.05 |
| P29 | 9.1 | 10.75 | 472.9 | 564.4 | 7.09 | 8.46 |
| P30 | 9.01 | 12.09 | 330.4 | 521.3 | 4.95 | 7.81 |
| P31 | 8.59 | 15.99 | 315 | 583.3 | 4.72 | 8.74 |
| P32 | 8.28 | 14.52 | 248.9 | 416 | 3.73 | 6.24 |
| P33 | 9.1 | 12.18 | 313.8 | 588 | 4.7 | 8.82 |
| P34 | 9.01 | 9.8 | 337.6 | 478.1 | 5.06 | 7.17 |
| P35 | 4.89 | 13.98 | 154.6 | 532 | 2.31 | 7.98 |
| P36 | 6.49 | 15.08 | 218.6 | 534 | 3.27 | 8.01 |
| P37 | 1.32 | 16.22 | 41.8 | 578.1 | 0.627 | 8.67 |
| P38 | 3.4 | 14.8 | 50.9 | 539 | 0.76 | 8.08 |
| P39 | 7.3 | 13.38 | 261.8 | 836.2 | 3.92 | 12.54 |
| P40 | 6.51 | 16.7 | 362.5 | 485.7 | 5.43 | 7.28 |
| P41 | 5.81 | 14.08 | 184 | 561.1 | 2.76 | 8.41 |
| P42 | 14.74 | 8.85 | 688 | 306.2 | 10.32 | 4.59 |
| P43 | 8.48 | 11.04 | 363 | 503.9 | 5.44 | 7.55 |
| P44 | 8 | 14.51 | 285.2 | 459.3 | 4.27 | 6.88 |
| P45 | 8.59 | 14.37 | 356 | 804.8 | 5.34 | 12.07 |
| P46 | 7.3 | 11.75 | 287.6 | 418.7 | 4.31 | 6.28 |
| P47 | 7.5 | 10.75 | 245 | 619.5 | 3.67 | 9.29 |
| P48 | 8.48 | 10.47 | 313.8 | 379 | 4.7 | 5.68 |
| P49 | 6.54 | 11.47 | 205.6 | 362.9 | 3.08 | 5.44 |
| P50 | 5.67 | 14.84 | 144.5 | 583 | 2.16 | 8.74 |
| Total | | | | | | |
| | **355.65** | **625.31** | **12930** | **25805.5** | **193.697** | **386.84** |
| Average | | | | | | |
| | **7.113** | **12.5** | **258.6** | **516.11** | **3.87** | **7.73** |

**Appendix II.**

**Table (II.1)** Effective dose relationship with KV and mA

| Patient | KV 120 | | KV 100 | |
|---|---|---|---|---|
| | mA | **ED 120** | mA | ED 100 |
| **P01** | 129/190 | **7.05** | 192/190 | 3.21 |
| **P02** | 179/190 | **7.81** | 210/190 | 2.97 |
| **P03** | 182/190 | **8.82** | 250/190 | 4.02 |
| **P04** | 240/190 | **8.74** | 167/190 | 5.7 |
| **P05** | 147/190 | **7.17** | 213/190 | 4.18 |
| **P06** | 250/190 | **7.28** | 209/190 | 3.9 |
| **P07** | 211/190 | **8.41** | 172/190 | 2.83 |
| **P08** | 217/190 | **6.88** | 95/190 | 2 |
| **P09** | 215/190 | **12.07** | 180/190 | 3.69 |
| **P10** | 154/190 | **4.87** | 221/190 | 4.75 |
| **P11** | 222/190 | **8.74** | 187/190 | 3.77 |
| **P12** | 180/190 | **5.67** | 210/190 | 3.73 |
| **P13** | 151/190 | **6.47** | 76/190 | 1.53 |
| **P14** | 148/190 | **5.31** | 192/190 | 3.21 |
| **P15** | 84/190 | **2.65** | 240/190 | 4.02 |
| **P16** | 163/190 | **10.24** | 167/190 | 5.7 |
| **P17** | 116/190 | **4.35** | 187/190 | 3.94 |
| **P18** | 176/190 | **6.93** | 56/190 | 1.06 |
| **P19** | 134/190 | **4.77** | 213/190 | 4.18 |
| **P20** | 187/190 | **13.64** | 209/190 | 3.9 |
| **P21** | 168/190 | **6.5** | 172/190 | 2.83 |
| **P22** | 158/190 | **9.36** | 95/190 | 2 |
| **P23** | 194/190 | **6.71** | 31/190 | 0.37 |
| **P24** | 165/190 | **5.44** | 250/190 | 5.6 |
| **P25** | 227/190 | **5.21** | 180/190 | 3.69 |
| **P26** | 129/190 | **9.56** | 202/190 | 5.77 |
| **P27** | 161/190 | **14.41** | 221/190 | 4.75 |
| **P28** | 179/190 | **7.05** | 201/190 | 3.78 |
| **P29** | 240/190 | **8.46** | 231/190 | 7.09 |
| **P30** | 200/190 | **7.81** | 229/190 | 4.95 |
| **P31** | 182/190 | **8.74** | 218/190 | 4.72 |
| **P32** | 147/190 | **6.24** | 210/190 | 3.73 |
| **P33** | 192/190 | **8.82** | 231/190 | 4.7 |
| **P34** | 226/190 | **7.17** | 229/190 | 5.06 |
| **P35** | 243/190 | **7.98** | 124/190 | 2.31 |
| **P36** | 222/190 | **8.01** | 165/190 | 3.27 |
| **P37** | 200/190 | **8.67** | 33/190 | 0.627 |
| **P38** | 250/190 | **8.08** | 86/190 | 0.76 |
| **P39** | 211/190 | **12.54** | 185/190 | 3.92 |
| **P40** | 132/190 | **7.28** | 165/190 | 5.43 |
| **P41** | 165/190 | **8.41** | 147/190 | 2.76 |
| **P42** | 217/190 | **4.59** | 375/190 | 10.32 |
| **P43** | 215/190 | **7.55** | 215/190 | 5.44 |
| **P44** | 176/190 | **6.88** | 203/190 | 4.27 |
| **P45** | 161/190 | **12.07** | 218/190 | 5.34 |
| **P46** | 157/190 | **6.28** | 185/190 | 4.31 |
| **P47** | 172/190 | **9.29** | 190/190 | 3.67 |
| **P48** | 222/190 | **5.68** | 215/190 | 4.7 |
| **P49** | 140/190 | **5.44** | 166/190 | 3.08 |
| **P50** | 197/190 | **8.74** | 144/190 | 2.16 |

**Appendix III.**

**Table (III.1)** Relationship between the effective dose, image quality (noise), and rotation time = 0.5

| Patient | SD120 | ED 120 | | SD100 | ED 100 |
|---|---|---|---|---|---|
| P01 | 10.11667 | 7.05 | | 6.433333 | 3.21 |
| P02 | 7.333333 | 7.81 | | 6.6 | 2.97 |
| P03 | 7.373333 | 8.82 | | 6.653333 | 4.02 |
| P04 | 7.373333 | 8.74 | | 6.736667 | 5.7 |
| P05 | 7.38 | 7.17 | | 6.776667 | 4.18 |
| P06 | 7.416667 | 7.28 | | 6.8 | 3.9 |
| P07 | 7.44 | 8.41 | | 6.81 | 2.83 |
| P08 | 7.48 | 6.88 | | 6.843333 | 2 |
| P09 | 7.483333 | 12.07 | | 6.87 | 3.69 |
| P10 | 7.64 | 4.87 | | 6.873333 | 4.75 |
| P11 | 9.93 | 8.74 | | 6.876667 | 3.77 |
| P12 | 9.94 | 5.67 | | 6.9 | 3.73 |
| P13 | 9.96 | 6.47 | | 6.906667 | 1.53 |
| P14 | 9.96 | 5.31 | | 6.906667 | 3.21 |
| P15 | 9.966667 | 2.65 | | 6.936667 | 4.02 |
| P16 | 10.00667 | 10.24 | | 6.943333 | 5.7 |
| P17 | 10.03333 | 4.35 | | 6.95 | 3.94 |
| P18 | 10.03667 | 6.93 | | 6.983333 | 1.06 |
| P19 | 10.06667 | 4.77 | | 7.01 | 4.18 |
| P20 | 10.06667 | 13.64 | | 7.01 | 3.9 |
| P21 | 10.07333 | 6.5 | | 7.016667 | 2.83 |
| P22 | 10.07333 | 9.36 | | 7.016667 | 2 |
| P23 | 10.07333 | 6.71 | | 7.033333 | 0.37 |
| P24 | 10.08333 | 5.44 | | 7.036667 | 5.6 |
| P25 | 10.08667 | 5.21 | | 7.036667 | 3.69 |
| P26 | 10.09333 | 9.56 | | 7.04 | 5.77 |
| P27 | 10.09667 | 14.41 | | 7.05 | 4.75 |
| P28 | 10.1 | 7.05 | | 7.05 | 3.78 |
| P29 | 10.11 | 8.46 | | 7.053333 | 7.09 |
| P30 | 10.11667 | 7.81 | | 7.06 | 4.95 |
| P31 | 10.13 | 8.74 | | 7.063333 | 4.72 |
| P32 | 10.13667 | 6.24 | | 7.066667 | 3.73 |
| P33 | 10.13667 | 8.82 | | 7.066667 | 4.7 |
| P34 | 10.14 | 7.17 | | 7.076667 | 5.06 |
| P35 | 10.15333 | 7.98 | | 7.1 | 2.31 |
| P36 | 10.16333 | 8.01 | | 7.15 | 3.27 |
| P37 | 10.17667 | 8.67 | | 7.17 | 0.627 |
| P38 | 10.2 | 8.08 | | 7.173333 | 0.76 |
| P39 | 10.21667 | 12.54 | | 7.176667 | 3.92 |
| P40 | 10.23333 | 7.28 | | 7.203333 | 5.43 |
| P41 | 10.23333 | 8.41 | | 7.243333 | 2.76 |
| P42 | 10.23333 | 4.59 | | 7.26 | 10.32 |
| P43 | 10.24 | 7.55 | | 7.266667 | 5.44 |
| P44 | 10.24667 | 6.88 | | 7.27 | 4.27 |
| P45 | 10.28 | 12.07 | | 7.273333 | 5.34 |
| P46 | 10.35 | 6.28 | | 7.303333 | 4.31 |
| P47 | 10.38333 | 9.29 | | 7.31 | 3.67 |
| P48 | 10.38333 | 5.68 | | 7.316667 | 4.7 |
| P49 | 10.42667 | 5.44 | | 7.406667 | 3.08 |
| P50 | 10.47333 | 8.74 | | 7.466667 | 2.16 |

Minimum value is in green, Average value is in yellow and Maximum value is in red

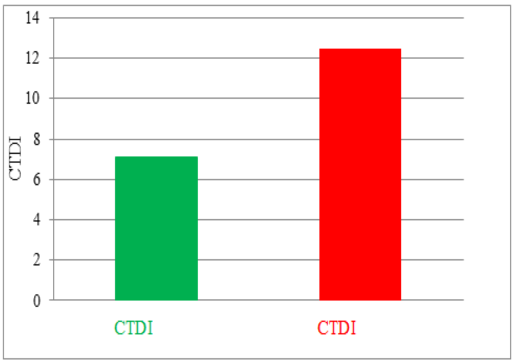



**Figure (1):** CTDI values for groups ***A*** (standard) and ***B*** (proposed protocol)

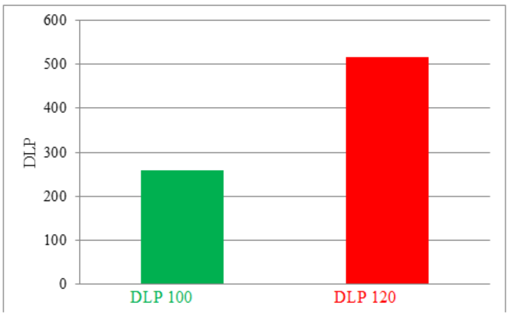



**Figure (2):** DLP values for groups ***A*** (standard) and ***B*** (proposed protocol).

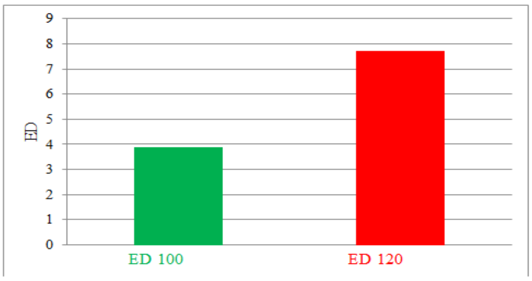
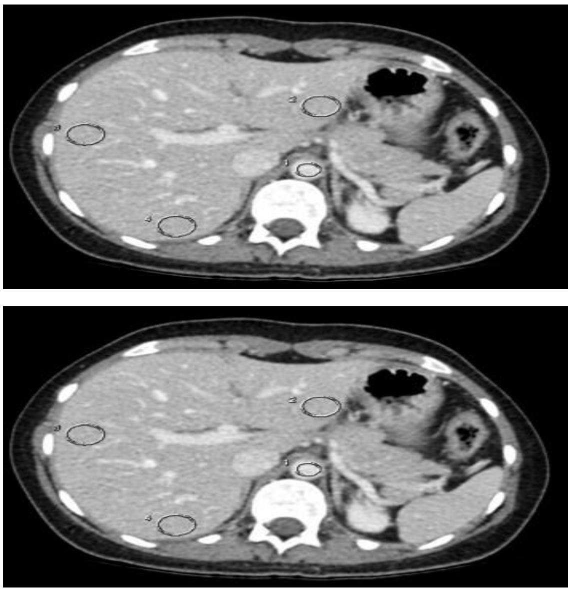



**Figure (3):** ED values for groups ***A*** (standard) and ***B*** (proposed protocol).



**a**

**b**

**Figure (4):** Computed Tomography image quality assessment of patient liver between **a** (standard protocol) and **b** (proposed protocol).

## 4. Discussion

Despite being one of the most significant medical discoveries of the last century, the CT scan has its own set of risks and side effects. In the United States alone, 29,000 more cancer cases are attributed to previous CT scans each year [22]. According to reports, abdominal CT scans subject patients to the most radiation of any CT scans. The radiology community has been studying a number of approaches to lower patient exposure while preserving diagnostic efficacy [23]. One of the best innovations for reducing patient dose in this field is the recently introduced iterative reconstruction approach [24]. The (proposed protocol) is used as an approach for iterative reconstruction [25,26]. The current study thus offers a quantitative assessment of the (proposed protocol's) performance as a novel iterative algorithm.

The dose modulation (auto mA) and voltage reduction from 120 KV to 100 KV were employed, resulting in a 50% reduction in the patient's effective dose when compared to group B (the proposed protocol) and group A (the standard protocol). The change of kV with the body (form and density) is essential to lowering the dose and maintaining the noise level [26].

The findings of the present investigation agreed with those of a study by Grosser et al. [27], which demonstrated that adaptive Statistical In complex hybrid imaging systems, iterative reconstruction (ASIR) enhanced the quality of low-dose CT (LD-CT) images. The two major shortcomings of the current study should be addressed in future research: First, screening was for patients with a BMI between 28 and 45 kg per square meter (BMI = 28 – 45 kg.m$^{-2}$), therefore, patients with a higher BMI should be examined. Second, the CT scan was for the abdominal area only, so it should include the rest of the body parts.

## Conclusions

The computed tomography protocol for overweight and obese patients, specifically for the abdominal region by modulation dose (voltage decrease from 120 kV to 100 kV, mAs auto), was suggested as a conclusion of the current study. As indicated in Tables 1 and in Figures 1, 2, and 3, Moreover, when the (CTDIvol, DLP, and effective dose) were significant and the *p*-value was less than 0.05, the exposure dose was lowered in half relative to the usual procedure. Although there are no absolute defined limits for patient radiation exposure, the goal is that radiation exposure from diagnostic imaging should be kept "as low as reasonably achievable" (ALARA).

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