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The Influence of mAs on Effective Dose and Image Quality in Chest CT scans Using RANDO Phantom

Fuzi Elkut [1 *], Jamal Almarkz [1], Hameda Ali Abrass [2], Mohamed Sryh,[3] Amna Abujnah [4], Seham Hafez [5], Fatma Elnuri [6]

[1] Faculty of Health Sciences, Elmergib University, Al-khums, Libya

[2] Department of physics, Faculty of Science, Elmergib University, Al-khums, Libya

[3] Faculty of Medicine, Elmergib University, Alkhoms, Libya

[4] Therapist, Radiotherapy Department, National Cancer Institute, Libya

[5] Radiology Department, Misurata Medical Center, Libya

[6] The Libyan Academy. Misrata, Libya.

[*] *Corresponding author:* fmelkut@elmergib.edu.ly

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Abstract:

Balancing radiation dose and image quality in chest CT scans is critical for patient safety and diagnostic accuracy. This study investigates the impact of milliampere-seconds (mAs) on effective radiation dose and image quality using a RANDO phantom. By systematically varying mAs settings (180–480 mAs) while maintaining constant tube voltage (kVp), radiation dose metrics (CTDIvol and dose-length product [DLP]) and image quality parameters (signal-to-noise ratio [SNR] and contrast-to-noise ratio [CNR]) were measured. Results demonstrated a linear increase in radiation dose with higher mAs, while improvements in SNR and CNR plateaued beyond 230 mAs. These findings highlight the importance of optimizing mAs settings to minimize radiation exposure while preserving diagnostic image quality, suggesting that dose reductions are achievable without compromising clinical utility.

Keywords: Contrast-to-noise ratio (CNR), DLP, Effective Dose, Signal-to-noise ratio (SNR).

تأثير مللي أمبير-ثانية (mAs)على الجرعة الفعالة وجودة الصورة في فحوصات الأشعة المقطعية للصدر باستخدام شبحRANDO

فوزي الكوت[1*]، جمال المركز[1]، حميدة ابوراس [2]، محمد سريح[3]، أمنة ابوجناح[4]، سهام حفيظ [5]،فاطمة النوري[6]

[1] كلية العلوم الصحية، جامعة المرقب، الخمس، ليبيا

[2] قسم الفيزياء، كلية العلوم، جامعة المرقب، الخمس، ليبيا

[3] كلية الطب، جامعة المرقب، الخمس، ليبيا

[4] أخصائي علاج، قسم العلاج الإشعاعي، المعهد الوطني للسرطان، ليبيا

[5] قسم الأشعة، مركز مصراتة الطبي، مصراتة، ليبيا

[6] لأكاديمية الليبية، مصراتة، ليبيا

الملخص

يُعد تحقيق التوازن بين جرعة الإشعاع وجودة الصورة في فحوصات الأشعة المقطعية للصدر أمرًا بالغ الأهمية لسلامة المرضى ودقة التشخيص. تهدف هذه الدراسة إلى دراسة تأثير عدد ملي أمبير-الثانية (mAs) على الجرعة الإشعاعية الفعالة وجودة الصورة باستخدام شبح RANDO. تم تغيير إعدادات mAs بشكل منهجي) من 180 إلى 480 mAs) مع الحفاظ على جهد الأنبوب (kVp) ثابتًا، وتم قياس مؤشرات الجرعة الإشعاعية) مثل CTDIvol ومنتج الطول والجرعة (DLP) إلى جانب معايير جودة الصورة) نسبة الإشارة إلى الضوضاء SNR ونسبة التباين إلى الضوضاء .(CNR أظهرت النتائج زيادة خطية في الجرعة الإشعاعية مع ارتفاع قيمةmAs ، في حين وصلت التحسينات في SNR و CNRإلى حالة من الثبات بعد 230 .mAs تؤكد هذه النتائج على أهمية تحسين إعدادات mAs لتقليل التعرض للإشعاع مع الحفاظ على جودة الصورة التشخيصية، مما يشير إلى إمكانية تقليل الجرعة دون التأثير على الفائدة السريرية.

الكلمات المفتاحية: نسبة التباين الي الضوضاء (CNR)، حاصل ضرب الجرعة في الطول(DLP)، الجرعة الفعالة، نسبة الاشارة الي الضوضاء(SNR)

Introduction

Computed tomography (CT) is a valuable diagnostic technique in medicine, providing detailed three-dimensional images of internal organs and tissues. However, the use of ionizing radiation in CT imaging raises concerns about potential health risks, such as increased risk of cancer. Computed tomography remains indispensable in modern diagnostics but necessitates careful balancing of radiation exposure risks (quantified via metrics like CTDI vol and DLP) against diagnostic image quality parameters such as SNR, and CNR, Therefore, it is necessary to improve imaging protocols to reduce the radiation dose to patients while maintaining sufficient image quality for accurate diagnosis There has been much discussion recently regarding the increasing number of indications for which helical CT is used and the associated radiation dose, and a growing number of studies indicate a more widespread use of CT as a primary imaging technique in a variety of clinical scenarios: the patient with chest and abdominal pain, suspected appendicitis, or suspected kidney stones. A major drawback of this increased use of helical CT is the increased radiation exposure. The radiation dose should also be limited because of the potential risk of side effects that can occur when patients undergo their first CT scan **[1]**.

Milliampere-second (mAs) is a crucial determinant in CT imaging, playing a vital role in shaping image quality. Higher mAs settings enhance the signal-to-noise ratio (SNR) and reduce image noise, thereby improving image clarity and contrast. However, these benefits come at the cost of increased radiation exposure to the patient, raising concerns about safety **[2,3]**.

The dose-length product (DLP) serves as an indicator of the cumulative radiation dose delivered during a CT scan. It incorporates the number of scans and the scan's total length **[4]**. Mathematically, DLP is expressed as the product of the volumetric CT dose index (CTDIvol) and the scan length. The definition of dose length factor as shown in equation 1.

$$\text{Dose-Length Product} = \text{CTDIvol} \times \text{scan length} \quad (1)$$

The CTDI is often determined using specialized dosimeters, though alternative measuremen[illegible]iques are available. While this approach demands specific equipment and is infrequently performed, th[illegible]s provide insights into the absorbed radiation dose. The CTDI is measured in gray (Gy) in the International System of Units, while the rad is also used as a conventional unit. The CTDI value essentially represents the dose distribution along the z-axis of a single CT scan capable of generating an image **[5]**.

This discussion aligns with evaluating the impact of mAs on radiation dose and image quality in chest CT scans using a RANDO Phantom as the testing model.

The effective dose is the average absorbed dose from uniform whole-body radiation that can produce the same total radiation damage as from partial irregular radiation to the body in question. The effective dose is calculated as a weighted average of the average absorbed dose to different organs and tissues in the body, where the weighting factor is the radiation damage to a particular organ (from whole-body radiation) as a fraction of the total radiation damage. **[4]**. Many factors affect image quality such as Kilovolt (KV), Mill ampere-second (MAS), scan time, pitch, FOV, sliced thickness, rotation time, CTDI and DLP.

Phantom studies enable systematic evaluation of trade-offs under controlled conditions **[6]**. This study aims to explores the impact of mill ampere-seconds (mAs) on radiation dose and image quality, specifically using a Sandro phantom, which simulates human tissue characteristics. obtain a good contrast image with the lowest radiation dose by giving a range of different mAs doses and evaluating the image quality.

Material and Method

In this study, a Phantom device type Rando was used to measure radiation dose The Rando Phantom was used as a model of the human body in this study. This model is made of materials that mimic the density of human tissue, allowing for accurate estimation of the radiation dose to the patients, as well as a. GE-16 CT scan: Chest CT scans were performed using a multislice CT scanner. The scanner was set to standard chest imaging protocols, with mAs values changed only to assess their effect on dose and image quality. and the Image J software and DICAM Viewer software were used. The measurement was carried out by imaging the pantone with a CT scan by taking a group of doses starting from 180 mas to 480 mas at the rest parameters are constant. After that, these images were taken and analysed by entering them first into the DICAM Viewer software, and then converting them to the image J program, where the ROI1 was determined at the level of the menbarium at the anterior and the ROI2 Posterior at the level of the Dorsal 3.

A DICOM viewer is a software application that can display and manipulate DICOM medical images.

Fig (1): Rando phantom used in this study

Image quality was assessed objectively using ImageJ software (version 1.8.0), developed by the National Institutes of Health (NIH), USA. The mean signal and standard deviation (StdDev) within the selected region of interest (ROI) were obtained to sequentially calculate the contrast-to-noise ratio (CNR) and signal-to-noise ratio (SNR). **[6]**.

The effective dose was calculated as shown in equation 2.

$$\textbf{Effective Dose} = \textbf{K x DLP} \ldots\ldots\ldots\ldots\ldots \quad \textbf{(2)}$$

Where: K represents the effective dose factor, which varies according to the imaged part of the body and according to age, **[7]**.

Table (1): the effective dose coefficient values for adults and children (according to the British study 2003)

Effective dose factor value [mSv. (mGy.cm)$^{-1}$]					The area of the body being photographed
Adult	10 years	5 years	1 year	Less than a year	
0.0021	0.0032	0.0040	0.0067	0.011	Brain
0.014	0.013	0.018	0.026	0.039	Chest
0.014	0.015	0.020	0.030	0.049	Abdomen
0.015	0.015	0.020	0.030	0.049	Pelvis

Contrast to noise ratio (CNR):

The contrast-to-noise ratio assesses the level of contrast between two different regions. Thus, two circular regions of interest (ROI1) in the lung and a second circular region in the soft tissue with higher density (ROI2) are measured, as shown in Figure 2. The contrast is determined by calculating the difference between the mean signal of RO12 and ROI1divided by the standard deviation of ROI2, as shown in equation 3.

$$CNR = \frac{\textit{mean signal of } ROI_2 - \textit{Mean signal of } ROI_1}{\textit{StdDev of } ROI_2} \ldots\ldots\ldots\ldots\ldots \quad \textbf{(3)}$$

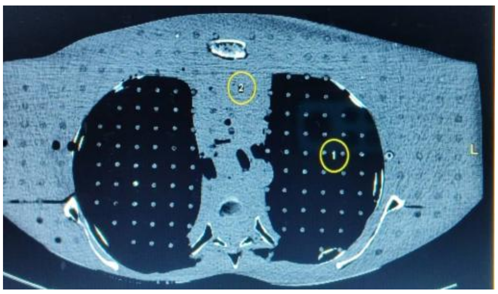

Fig (2): shows ROI in axial chest CT scan

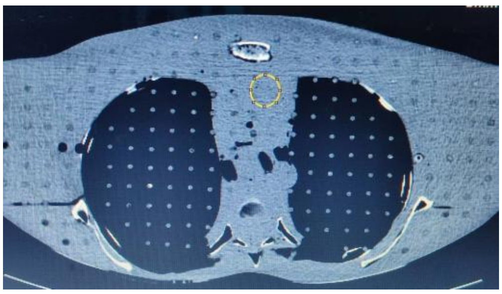

Fig (3): show selecting ROI

Signal to noise ratio (SNR):

To determine the signal-to-noise ratio (SNR), a uniform area within the image is selected as the region of interest (ROI), and its mean signal intensity is measured. The SNR is then calculated by dividing this mean signal by the standard deviation of the same ROI, as illustrated in Equation 4. Estimating SNR is a widely used approach for quantifying image noise. **[6]**. The threshold SNR for detecting objects in a medical image is ≥ 5**[8]**.

$$SNR = \frac{mean\ signal\ of\ ROI}{StdDev\ of\ ROI} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad \textbf{(4)}$$

Result and Discussions

The Table 2 shows us the results obtained when the phantom was used in imaging until all parameters were fixed on the CT device except for MAS, which was variable. MAS values were taken from 180 to 480, and the values of effective dose and DLP were calculated. The table also shows the values of CNR and SNR for which the images were analyzed using Image J The table shows how these values change as the MAS value increases, indicating the relationship between radiation dose and image quality.

that image quality (SNR and CNR) increases as the dose (MAS) increases, but reaches a point where the increase stops, indicating that increasing dose beyond this point does not significantly improve image quality

Table (2): the result of mean CNR, mean SNR and Effective dose

SNR	CNR	Effective dose (mGy)	DLP (mGy)	MAS
11	9	5.59	399.70	180
13.4	10.7	5.9	421.82	190
14.6	11.02	6.21	444.02	200
14.85	12.2	6.52	466.22	210
15.1	12.4	6.87	490.73	220
15.21	12.61	7.18	513.34	230
15.64	12.9	7.49	535.34	240
16.1	13.6	7.8	557.65	250
16.7	13.76	8.11	579.95	260
16.9	14.9	8.43	602.26	270
17	16.1	8.74	624.57	280
17.33	17.07	9.05	646.87	290
17.9	17.56	9.36	669.18	300
18.1	18.6	9.99	713.79	320
18.7	18.9	10.3	736.09	330
18.9	19.1	10.61	758.40	340
19.27	19.7	11.24	803.04	360
19.5	19.89	11.55	825.32	370
19.9	20.11	11.86	847.6	380
20.1	20.69	12.17	869.93	390
20.22	21.11	12.49	892.24	400
21.05	21.24	12.8	914.54	410
21.26	21.8	13.11	936.85	420
21.76	22.06	13.42	959.15	430
22.4	23.25	13.74	981.46	440
22.6	24.01	14.053	1003.7	450
23.2	25.08	14.36	1026	460
23.66	26.3	14.67	1048.3	470
24.7	26.74	14.99	1070.6	480

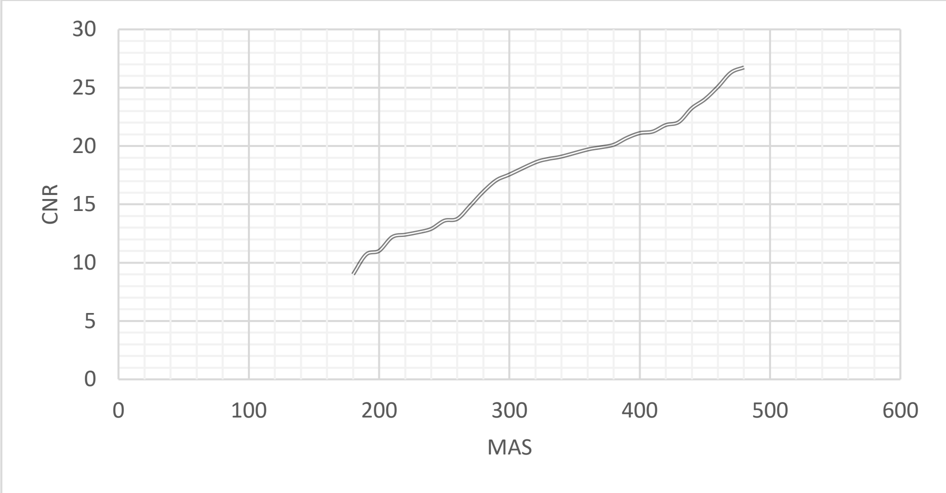

Fig (4): The chart graphic shows the relation between mill ampere second and Contrast-to-noise-ratio

The relationship between MAS and CNR in figure 4 shown as a gradual increase with the increase of MAS.

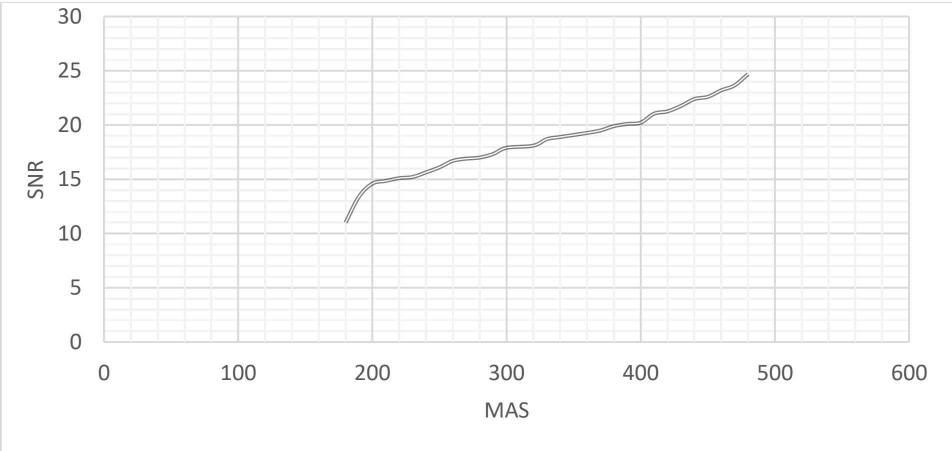

Fig (5): The chart graphic shows the relation between mill ampere second and signal-to-noise ratio

The relationship between MAS and SNR in figure 5 shown as a gradual increase with the increase of MAS.

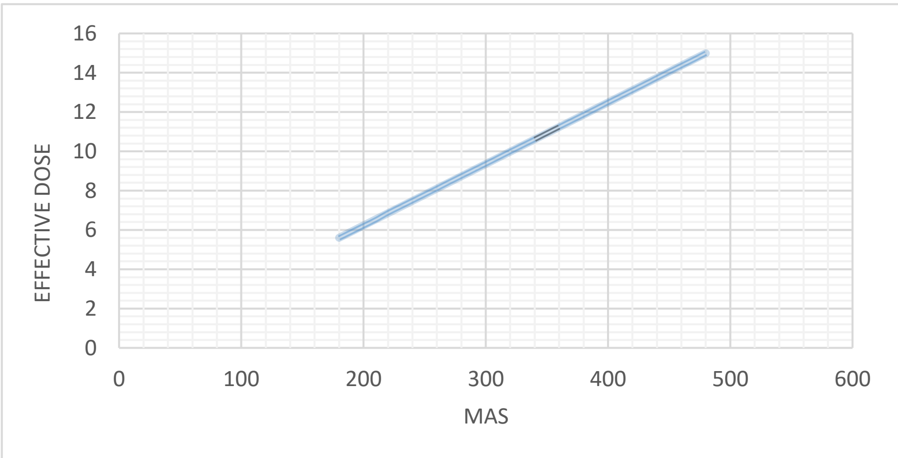

Fig (6): The chart graphic shows the relation between mill ampere second and Effective dose

The relationship between MAS and effective dose in the figure 6 as shown a linear increase in the world dose with increasing MAS Through the values of the results, CNR, SNR, and MAS, it is clear that there is a direct relationship, such that the more the amount of radiation dose increases, the more the image quality increases in clarity, but at a certain value, the values of SNR and MAS begin to converge, which indicates the convergence of image quality at 230 MAS, as shown in Table 2.

Conclusion

This study evaluated the relationship between mAs, radiation dose, and image quality in chest CT scans using a RANDO phantom. Image J software facilitated objective assessment of SNR and CNR, revealing that image quality metrics improved with increasing mAs but reached an area of little variation at 230 mAs, beyond which further increases in mAs yielded diminishing returns. Radiation dose, quantified by CTDIvol and DLP, exhibited a linear correlation with mAs. These results highlight the potential for optimizing chest CT protocols by reducing mAs settings to levels that maintain diagnostically sufficient image quality while significantly lowering patient radiation exposure. Future studies should validate these findings in clinical settings and explore complementary techniques, to further enhance dose efficiency without sacrificing diagnostic precision.

References

1. Zhang, M., Gu, S., & Shi, Y. (2022). "The use of deep learning methods in low dose computed tomography image reconstruction: a systematic review. Complex & intelligent systems", 8(6), 5545-5561.
2. Elkut F, Shalbi SM. "A Review of mAs Optimization Strategies in CT Imaging: Maximizing Quality and Minimizing Dose Simultaneously". Journal of Educational. 2025.
3. Seeram, E. (2022). "Computed Tomography-E-Book: Physical Principles, Patient Care, Clinical Applications, and Quality Control". Elsevier Health Sciences
4. INSTITUTE OF PHYSICAL SCIENTISTS IN MEDICINE (UK) recommended standards for the routine performance testing of diagnostic x-ray imaging systems, IPEM report 91 (2005).
5. Philipp Feldle aJan-Peter Grunz Henner Huflage a Daniel Halt bSimone Schüle b Leonie Sauer b Arthur Wunderlich c Meinrad Beer c Thorsten Alexander Bley a Carsten Hackenbroch) 2023). Organ-based tube current modulation versus spectral shaping via tin pre filtration: What does bismuth breast shielding add in low-dose lung CT https://doi.org/10.1016/j.ejrad.2023.111157
6. Cardona A, Tomancak P. "Current challenges in open-source bioimage informatics". Nat Methods. 2012;9(7):661-665. Published 2012 Jun 28. doi:10.1038/nmeth.2082.
7. NRPB-W67, P.C. SHRIMPTON & M.C. HILLIER, "Doses from Computed Tomography (CT) Examination in the UK", 2003 Review.
8. Magnus Båth,"Evaluating imaging systems: practical applications, Radiation Protection Dosimetry" Volume 139, Issue 1-3, 2010
9. Conference of Radiation Control Program Directors home page. Available at: http://www.crcpd.org. Accessed June 26, 2002
10. Ferreira, T., & Rasband, W. (2012). ImageJ user guide: IJ 1.42 r. National Institute of Health.