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Evaluation of Dose Variability in Serial Abdominal CT Examinations Conducted Using a Multidetector CT Scanner

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Abstract— Background: ***Multidetector computed tomography (MDCT) represents a significant advancement in CT imaging. However, with the increasing frequency of repeated CT examinations, concerns about cumulative radiation exposure arise. Minor variations in patient positioning, scan length, and technical parameters between follow-up scans can influence dose. This study aimed to investigate the variability in radiation dose among serial abdominal CT examinations performed using MDCT scanners using the same scanner with a standardized scanning protocol.***

Materials & Methods: ***This cross-sectional study received approval from the Institutional Review Board (IRB) of the King Abdullah International Medical Research Centre (KAIMRC). Data on the computed tomography dose index volume (CTDIvol) and dose-length product (DLP) were retrospectively extracted, compiled, and analyzed for 140 patients (100 males, 40 females) who underwent two consecutive non-contrast Abdomen CT (AB-CT) examinations between January 2022 and June 2023. All scans were performed on the same MDCT system Philips, equipped with automated exposure control, using data retrieved from the RIS/PACS database at the Medical Imaging CT Unit, King Abdulaziz Medical City (KAMC), Riyadh, Saudi Arabia.***

Results: ***This study found no statistically significant variation in radiation dose metrics between the two CT scans.; mean CTDIvol decreased from 33.27 to 31.26 mGy and DLP from 894.33 to 829.34 mGy·cm. technical parameters, including tube voltage, exposure time, table height, and slice thickness, showed minimal, non-significant variation, indicating consistent scanning protocols across both visits.***

Conclusion: ***The analysis confirmed no significant differences in radiation dose or scan parameters between the two follow-up CT visits. These findings suggest consistent application of imaging protocols and effective use of dose management strategies, including automated exposure control on the MDCT scanner.***

Keywords: ***Non-enhanced Computed Tomography, Dose Length Product (DLP), Computed Tomography Dose Index (CTDI), Multi-detector Computed Tomography (MDCT).***

I. INTRODUCTION

Computed Tomography (CT) has revolutionized diagnostic imaging by enabling rapid, high-resolution visualization of anatomical structures, particularly in the abdomen. Multidetector CT (MDCT) scanners allow for faster image acquisition, improved spatial resolution, and greater diagnostic accuracy. However, the associated ionizing radiation exposure raises significant concerns, especially when patients undergo serial or follow-up scans. Several studies have identified substantial variations in radiation doses administered for similar examinations, raising questions about dose optimization and standardization [1,3]. Radiation dose variability arises from multiple sources, including differences in scanner models, operator-dependent parameters, patient body habitus, and lack of standardized imaging protocols. Although dose-reduction technologies like automatic exposure control (AEC) and iterative reconstruction (IR) are available. However, the use of automated tube potential selection, these tools are not uniformly utilized or optimized across institutions [2,4,5,7]. Automatic exposure control mechanisms have demonstrated

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effective dose optimization by adjusting tube current in real time based on patient size and attenuation characteristics [2]. Similarly, iterative reconstruction methods also help reduce image noise, allowing lower radiation doses while keeping image quality good. [4,7]. Studies also suggest that automated attenuation-based tube potential selection enhances dose effectiveness by adapting voltage settings to individual patients [5]. However, patient-specific factors such as obesity continue to pose challenges in dose optimization due to increased radiation requirements for adequate image quality [6]. Significant dose variations have also been observed in repeat CT examinations, even when conducted on the same patient and scanner, highlighting the importance of consistent scanning protocols and operator training [3,9]. Given the potential biological risks of cumulative radiation exposure, it is critical to adhere to the ALARA (As Low As Reasonably Achievable) principle, not only by minimizing dose but also by reducing the biological impact of ionizing radiation [10,11]. Future strategies must incorporate dose-awareness training, protocol standardization, and technological advancements to mitigate these risks [12]. The aims of the study is to assess the variability in radiation dose among serial abdominal CT examinations performed using MDCT scanners. The objective is to identify key contributors to dose variation and propose recommendations for standardizing protocols and implementing dose-reduction strategies.

II. OBJECTIVE OF THE STUDY

Aim of the Study:

This study aimed to investigate the variability in radiation dose among serial abdominal CT examinations performed using MDCT scanner using the same scanner with a standardized scanning protocols.

Specific Objectives:

To evaluate and compare the differences in CTDIvol and DLP between serial abdominal CT examinations conducted on the same MDCT equipment.

To identify both direct and indirect factors influencing radiation dose variations observed in consecutive CT examinations.

III. MATERIAL AND METHODS

The Research Centre (KAIMRC) and the Institutional Review Board (IRB) waived the need for written consent because of the nature of the study as retrospective design. The research was conducted in the CT Unit of the Medical Imaging Department at KAMC, Riyadh, Saudi Arabia. The study focused on reviewing and analyzing follow-up abdominal CT scans conducted on the same MDCT. Data were retrospectively retrieved from the RIS/PACS system for the period between January 2022 and June 2023. Two primary dose metrics such as CTDIvol and DLP were extracted for analysis. To reduce potential bias, predefined inclusion and exclusion criteria were applied during data selection.

Inclusion Criteria:

Adult patients aged 16 years and older

Follow-up non-contrast CT abdomen examinations performed on the same scanner

Exclusion Criteria:

Pediatric patients (under 16 years of age)

Pregnant patients

CT chest examinations involving contrast media (contrast-enhanced scans)

Patients:

A total of 140 patients (100 males, 40 females) with a mean initial CT scan age of 61.2 ± 11.2 years were included who underwent two serial non-contrast abdomen CT (AB-CT) examinations using a Philips MDCT scanner. The median interval between the two scans was approximately three months, with a range of 4 to 16 weeks.

Exposure Parameters and Image Acquisition:

Data on the CTDIvol and DLP were retrospectively extracted, compiled, and analyzed for all included patients. Both CT examinations were performed using the same Philips MDCT scanner at the CT Unit of the Medical Imaging Department, MNGHA-KAMC. The scanner was equipped with automatic exposure control (AEC) technology to optimize radiation dose during image acquisition.

IV. RESULTS

As in the Table 1, a total of 140 patients underwent two consecutive non-contrast abdomen CT examinations on the same MDCT scanner. The primary aim was to assess the variability in radiation dose and scanning parameters between the two visits.

Radiation Dose Metrics:

The mean CTDIvol for the first visit was 33.27 ± 29.81 mGy, while the second visit recorded a slightly lower mean of 31.26 ± 28.48 mGy. Similarly, the Dose-Length Product (DLP) decreased from a mean of 894.33 ± 596.22 mGy·cm in the first scan to 829.34 ± 643.29 mGy·cm in the follow-up scan. However, statistical analysis revealed no significant difference in CTDIvol ($Z = -0.316$, $p = 0.614$) or DLP ($Z = -0.109$, $p = 0.812$) between the two examinations.

Technical Imaging Parameters:

It is demonstrated that minimal variation between the two CT sessions. The mean table height was 164.02 ± 15.22 cm during the first visit and 160.22 ± 17.44 cm during the second ($Z = -0.314$, $p = 0.780$). Tube voltage (kVp) decreased slightly from 125.80 ± 4.16 to 124.20 ± 2.24 ($Z = -0.622$, $p = 0.612$). Mean exposure time increased from 555.45 ± 100.28

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ms to 573.18 ± 120.55 ms (Z = -0.525, p = 0.565), while slice thickness remained consistent at 3.35 ± 0.98 mm and 3.34 ± 0.95 mm for the first and second visits, respectively (Z = -0.344, p = 0.626). None of these differences reached statistical significance, indicating stable application of scanning protocols across examinations. The figure 1 below illustrates the mean values for each key parameter across both visits, highlighting the consistency in scanning practices. Despite minor fluctuations, the analysis confirmed no significant differences in radiation dose or scan parameters between the two follow-up CT visits. These findings suggest consistent application of imaging protocols and effective use of dose management strategies, including automated exposure control on the MDCT scanner.

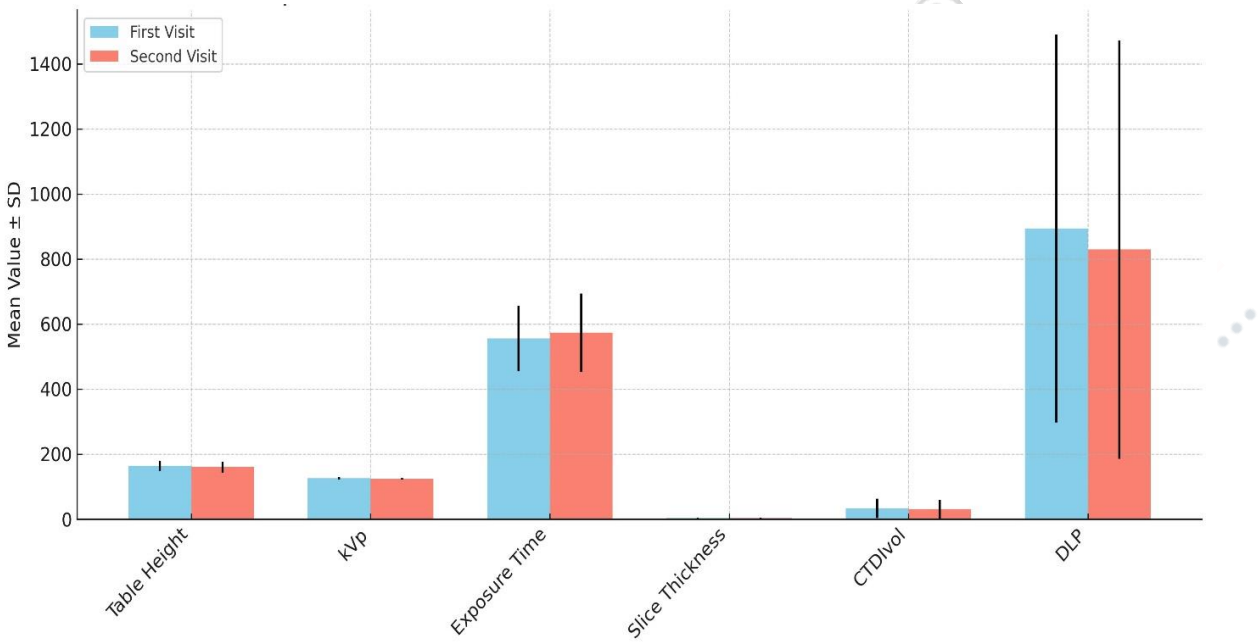

Figure 1: Comparative analysis of technical parameters between the first and second CT visits

Table 1: CT Parameter

Parameters		Mean	Std. Deviation	Minimum	Maximum	Percentiles			Test statistic= Z	P value
						25th	50th (Median)	75th		
Table height	First visit	164.02	15.22	105.40	209.20	145.52	167.12	165.00	-0.314	0.780
	Second visit	160.22	17.44	119.00	219.00	151.43	168.20	164.48		
KVP	First visit	125.80	4.16	100.00	150.00	130.00	130.00	130.00	-0.622	0.612
	Second visit	124.20	2.24	100.00	130.00	130.00	130.00	130.00		
Exposure time	First visit	555.45	100.28	310.00	900.00	500	500.00	600	-0.525	0.565
	Second visit	573.18	120.55	320.00	1000.00	500	500	600		
Slice thickness	First visit	3.35	0.98	0.75	5.00	3.20	3.35	3.35	-0.344	0.626
	Second visit	3.34	0.95	0.74	5.00	3.20	3.35	3.35		
Computed tomography dose index volume	First visit	33.27	29.81	3.64	150.47	11.22	21.32	32.48	-0.316	0.614
	Second visit	31.26	28.48	3.55	105.44	10.26	20.30	30.10		
Dose length Product	First visit	894.33	596.22	100.43	2836.25	525.45	810.15	1100.1	-0.109	0.812
	Second visit	829.34	643.29	56.88	3431.25	429.21	713.11	981.21		

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V. DISCUSSION

The present study evaluated intraindividual variability in radiation dose and technical parameters between two consecutive non-contrast abdomen CT examinations performed on the same MDCT scanner. The analysis of 140 patient pairs demonstrated no statistically significant differences in key radiation dose indices (CTDIvol and DLP) or imaging parameters (tube voltage, exposure time, table height, and slice thickness) between visits. These findings are aligned with previous literature suggesting that consistent protocol adherence and scanner technology can minimize dose variability. The slight decrease in mean CTDIvol and DLP values between the first and second scans (from 33.27 to 31.26 mGy and from 894.33 to 829.34 mGy·cm, respectively) who also reported minor, non-significant dose fluctuations throughout consecutive CT scans conducted using the same scanner with consistent, predefined imaging protocols. This supports the concept that variability in radiation exposure can occur even under controlled conditions but generally remains within a narrow range when scanner settings and patient positioning are consistent [20]. Moreover, the findings are consistent emphasized that while intraindividual dose variability is common in oncological follow-up imaging, such variability is often clinically insignificant when standardized protocols are strictly followed. The current results further validate this assertion, as dose metrics and technical parameters did not show meaningful change [16].

The lack of statistically significant differences in technical parameters like tube voltage, exposure time, and slice thickness indicate robust protocol reproducibility and operator consistency. It highlighted the significant impact of technologist performance on dose variation, suggesting that technologist training and protocol standardization are critical in achieving dose consistency. The minimal variation seen in this study suggests effective technologist performance and strong institutional quality control [17]. Additionally, the use of automated exposure control and iterative reconstruction techniques, commonly available in modern MDCT systems, likely contributed to dose consistency. While these specific technologies were not directly assessed in this study, their implementation in contemporary scanners is known to facilitate dose optimization without compromising image quality [18]. The results also align with the International Commission on Radiological Protection (ICRP) guidelines [19], which emphasize the importance of justification and optimization principles in CT imaging. The observed consistency in radiation dose reinforces the effective application of the ALARA (As Low As Reasonably Achievable) principle, as also supported by Sodhi et al. in the context of pediatric imaging [21]. Despite the observed consistency, the relatively wide standard deviations in CTDIvol and DLP values highlight the inherent individual variability due to patient size, anatomical differences, or slight positioning changes—factors that may influence dose delivery even under identical scanning protocols. These variations underscore the importance of individualized dose management and the need for continued monitoring to maintain optimization across different patient populations [14,15].

VI. CONCLUSION

There was no statistically significant difference in the radiation dose of follow-up CT scans done using the same CT scanner with an identical imaging protocol. However, the study demonstrates that modern MDCT systems, when combined with standardized protocols and skilled technologists, can achieve consistent radiation dose delivery across follow-up abdomen CT scans. The findings support existing literature and reinforce the importance of quality assurance in CT imaging practices to ensure patient safety and diagnostic consistency over time.

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