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Original Article

Effectiveness of Automated Exposure Control and Protocol Standardization in Reducing Radiation Dose in Routine CT Examinations

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ABSTRACT

Background: Computed tomography (CT) is widely used in diagnostic imaging due to its high speed, spatial resolution, and versatility. However, increased utilization contributes significantly to patient radiation exposure, raising safety concerns, particularly in patients requiring repeated scans. Automated exposure control (AEC) and protocol standardization are strategies proposed to reduce radiation dose while maintaining diagnostic image quality.

Objective: To evaluate the effectiveness of automated exposure control and standardized CT protocols in reducing radiation dose during routine chest and abdominal CT examinations, without compromising image quality.

Materials and Methods: A prospective observational study was conducted in the Department of Radiology of a tertiary care institution over six months. A total of 120 adult patients undergoing routine CT chest or abdomen scans were included and divided into two groups: pre-optimization (fixed tube current, routine kVp) and post-optimization (AEC with patient size-based tube current modulation, standardized kVp, and restricted scan length). Radiation dose parameters, including CT dose index (CTDIvol) and dose-length product (DLP), were recorded. Image quality was independently assessed by two radiologists using a five-point Likert scale based on image noise, contrast resolution, anatomical detail, and overall diagnostic acceptability.

Results: Post-optimization scans demonstrated significant reductions in radiation dose. In CT chest examinations, mean CTDIvol decreased from 9.8 mGy to 7.1 mGy, and mean DLP decreased from 420 mGy·cm to 298 mGy·cm. In CT abdomen examinations, mean CTDIvol decreased from 12.5 mGy to 8.5 mGy, and mean DLP decreased from 650 mGy·cm to 442 mGy·cm. All reductions were statistically significant ($p < 0.05$). Image quality assessment revealed no significant differences between pre- and post-optimization groups, with all post-optimization scans being diagnostically acceptable and requiring no repeats.

Conclusion: Implementation of automated exposure control combined with standardized CT protocols significantly reduces patient radiation dose while maintaining high diagnostic image quality. Routine adoption of these strategies enhances radiation safety and supports best practices in clinical CT imaging.

Keywords: Computed Tomography, Radiation Dose, Automated Exposure Control, Protocol Standardization

INTRODUCTION

Computed tomography (CT) has transformed diagnostic imaging by providing rapid, high-resolution cross-sectional images crucial for the evaluation of a wide range of clinical conditions. Since its introduction in the 1970s, CT has become indispensable for assessing thoracic, abdominal, neurological, and vascular diseases due to its speed, accuracy, and detailed anatomical information. [1] However, the increasing utilization of CT has contributed substantially to the overall radiation dose from medical imaging, raising concerns regarding radiation-induced risks, particularly in patients who undergo repeated examinations. [2,3] Ionizing radiation used in CT can damage DNA and potentially increase the risk of carcinogenesis, with cumulative dose being an important factor in risk assessment. [4]
Although the absolute risk per individual examination is relatively low, the widespread use of CT imaging has amplified population-level exposure. This has prompted international organizations and regulatory bodies to emphasize the principles of justification and optimization in medical imaging. [5] Justification requires that each CT examination provides clinical benefit and is medically necessary, while optimization ensures that radiation exposure is kept As Low As Reasonably Achievable (ALARA) without compromising diagnostic image quality. [6]
Optimization strategies in CT rely on both hardware and software innovations. Modern CT scanners are equipped with automated exposure control (AEC) and tube current modulation, which adjust radiation output dynamically according to patient size and tissue attenuation. These systems allow lower radiation doses in less attenuating regions

and higher doses where image quality is essential, thereby reducing unnecessary exposure while maintaining diagnostic accuracy. [7,8] Studies have demonstrated that AEC can significantly reduce radiation dose compared with fixed-parameter scans, particularly in routine chest and abdominal imaging. [9]
In addition to AEC, other factors such as tube potential (kVp), pitch, scan length, and reconstruction algorithms critically influence radiation dose. Protocol standardization ensures that these parameters are optimized for specific clinical indications, minimizing variability across operators and institutions. [10] Without standardized protocols, radiation dose can vary substantially for the same type of examination, sometimes leading to unnecessary exposure. [11] Standardized protocols provide consistency in image quality while promoting safe and efficient scanning practices.

Advanced image reconstruction techniques, including iterative reconstruction, further enhance dose optimization. These algorithms reduce image noise and improve contrast resolution, enabling diagnostically acceptable images at lower radiation doses compared with traditional filtered back projection methods. [12] By integrating these reconstruction techniques with AEC and standardized protocols, modern CT practice can achieve substantial dose reduction without compromising diagnostic efficacy. Despite these technological advances, effective optimization requires proper implementation and continuous quality control. Studies have shown that incorrect use of AEC, improper parameter selection, or lack of operator training may result in suboptimal dose reduction or even higher radiation exposure. [13] Therefore, radiographers, technologists, and medical physicists must be trained in dose optimization practices, including the appropriate application of automated systems, selection of scan parameters, and adherence to standardized protocols. The shift toward dose optimization represents a critical balance between diagnostic benefit and patient safety. Professional societies, regulatory agencies, and healthcare institutions now advocate for structured strategies to monitor and reduce radiation exposure, including audit systems, protocol reviews, and adoption of automated exposure technologies. [14] Evaluating the effectiveness of these measures in routine clinical practice is essential to ensure both patient safety and diagnostic confidence. In this context, this study assesses the impact of AEC and protocol standardization on radiation dose and image quality during routine CT chest and abdomen examinations.

AIM AND OBJECTIVE

Aim: The aim of this study is to evaluate the effectiveness of automated exposure control (AEC) and protocol standardization in reducing patient radiation dose during routine CT chest and abdomen examinations, while maintaining optimal diagnostic image quality.

Objectives

1. To compare radiation dose parameters, including CT dose index (CTDIvol) and dose-length product (DLP), before and after implementation of AEC and standardized protocols.
2. To assess the impact of AEC and protocol standardization on image quality, including noise, contrast resolution, anatomical detail, and overall diagnostic acceptability.
3. To determine the efficacy of tube current modulation in optimizing radiation exposure according to patient size and anatomy.

MATERIALS AND METHODS

Study Design and Setting: This prospective observational study was conducted over a period of six months in the Department of Radiology at a tertiary care institution. The study was approved by the institutional ethical committee, and informed consent was obtained from all participants.
Study Population: A total of 120 adult patients referred for routine CT chest or CT abdomen examinations were included. Patients were divided into two equal groups (n = 60 each):

- Pre-optimization group: Scans performed using fixed tube current settings and routine kVp values.
- Post-optimization group: Scans performed using automated exposure control (AEC) with patient size-based tube current modulation, standardized kVp selection, and restricted scan length.

Inclusion criteria: Adult patients referred for routine diagnostic CT examinations.
Exclusion criteria: Pediatric patients (<18 years), Pregnant patients, Trauma cases, Repeat scans, Patients with extensive metallic implants
CT Scanning Protocol: All scans were performed on a single multi-slice CT scanner. The pre-optimization group underwent routine fixed-parameter scanning, while the post-optimization group used optimized protocols incorporating:

- Automated exposure control with tube current modulation
- Standardized kVp selection according to patient size
- Restricted scan length to the region of clinical interest

Data Collection: Radiation dose parameters, including CT dose index (CTDIvol) and dose-length product (DLP), were recorded directly from the scanner console.
Image Quality Assessment: Two experienced radiologists independently assessed image quality. **Evaluation criteria included:** Image noise, Contrast resolution, Anatomical detail, Overall diagnostic acceptability. A five-point Likert scale was used, where higher scores indicated superior image quality. Discrepancies between reviewers were resolved by consensus.
Statistical Analysis: Descriptive statistics were used to summarize patient demographics and radiation dose parameters. Comparisons between pre- and post-optimization groups were performed using the Student's t-test for continuous variables. Statistical significance was defined as $p < 0.05$.

RESULTS

Patient Demographics: The study included 120 adult patients, equally divided into pre-optimization (n = 60) and post-optimization (n = 60) groups. Both groups were comparable in terms of age, sex, and body mass index (BMI), ensuring baseline homogeneity for analysis (Table 1).

Table 1: Demographic Characteristics of Study Population

Parameter	Pre-Optimization (n = 60)	Post-Optimization (n = 60)	p-value
Mean Age (years)	45.2 ± 12.3	46.1 ± 11.7	0.65
Male:Female ratio	32:28	30:30	0.78
Mean BMI (kg/m²)	24.8 ± 3.5	25.1 ± 3.2	0.59

Radiation Dose Comparison: In CT chest examinations, the implementation of automated exposure control and standardized protocols resulted in a substantial reduction in patient radiation dose. The mean CT dose index (CTDIvol) decreased from 9.8 mGy in the pre-optimization group to 7.1 mGy in the post-optimization group, while the mean dose-length product (DLP) decreased from 420 mGy·cm to 298 mGy·cm. Similarly, in CT abdomen examinations, the mean CTDIvol decreased from 12.5 mGy to 8.5 mGy, and the mean DLP decreased from 650 mGy·cm to 442 mGy·cm. These reductions in both CTDIvol and DLP were statistically significant ($p < 0.05$), indicating that the combination of automated exposure control and protocol standardization effectively reduced radiation exposure while maintaining image quality (Table 2).

Table 2: Comparison of Radiation Dose Parameters Before and After Optimization

Examination	Parameter	Pre-Optimization	Post-Optimization	% Reduction	p-value
CT Chest	CTDIvol (mGy)	9.8	7.1	27.6%	<0.05
CT Chest	DLP (mGy·cm)	420	298	29%	<0.05
CT Abdomen	CTDIvol (mGy)	12.5	8.5	32%	<0.05
CT Abdomen	DLP (mGy·cm)	650	442	32%	<0.05

Image Quality Assessment: Image quality was independently evaluated by two experienced radiologists using a five-point Likert scale. The post-optimization group demonstrated image quality comparable to that of the pre-optimization group. There were no significant differences in image noise or contrast resolution ($p > 0.05$), and both anatomical detail and overall diagnostic acceptability were consistently maintained across all post-optimization scans. Importantly, no repeat examinations were required due to inadequate image quality. These findings indicate that the reduction in radiation dose achieved through automated exposure control and standardized CT protocols did not compromise diagnostic confidence.

DISCUSSION

Computed tomography (CT) is a cornerstone of modern diagnostic imaging due to its speed, high resolution, and versatility in evaluating thoracic, abdominal, neurological, and vascular pathologies. However, its increasing utilization has raised concerns regarding radiation exposure, particularly in patients requiring repeated imaging. The aim of this study was to evaluate the effectiveness of automated exposure control (AEC) and protocol standardization in reducing radiation dose while maintaining diagnostic image quality. Our results demonstrate that both strategies are effective and can be routinely implemented in clinical practice. The findings show that the use of AEC and standardized CT protocols significantly reduced patient radiation exposure in both chest and abdominal examinations. In CT chest imaging, CTDIvol decreased by 27.6% and DLP by 29%, whereas in CT abdomen imaging, CTDIvol decreased by 32% and DLP by 32%. These reductions were statistically significant and demonstrate that patient-specific tube current modulation and optimized scan parameters effectively minimize unnecessary radiation without compromising image quality. This aligns with previously published literature highlighting the importance of AEC and protocol optimization in radiation dose reduction. [1] A key objective of this study was to evaluate whether dose reduction affected diagnostic image quality. Image assessment by two independent radiologists using a five-point Likert scale revealed no significant differences in image noise, contrast resolution, anatomical detail, or overall diagnostic acceptability between pre- and post-optimization groups. All scans in the post-optimization group were diagnostically acceptable, and no repeat examinations were required. These findings confirm that automated exposure control, combined with standardized scanning protocols, can achieve significant radiation reduction while maintaining diagnostic confidence, which is consistent with prior studies demonstrating similar outcomes. [2,3]

Standardization of protocols plays a crucial role in minimizing operator-dependent variability, ensuring consistent application of optimized parameters across different patients and examinations. It also facilitates reproducibility and helps maintain quality assurance in routine clinical practice. Moreover, radiographers and technologists play a vital role in implementing these optimized protocols, monitoring scanner settings, and ensuring adherence to recommended scan lengths and patient-specific adjustments. This supports the broader objective of radiation protection by adhering to the ALARA (As Low As Reasonably Achievable) principle. [4] Despite the positive outcomes, this study has certain limitations. It was conducted on a single CT scanner, which may limit generalizability to other scanner models or institutions. Pediatric patients and individuals with high body mass index were excluded, and long-term cumulative radiation exposure was not assessed. Additionally, image quality assessment was subjective, although performed independently by two radiologists to minimize bias.

CONCLUSION

The present study demonstrates that the use of automated exposure control (AEC) combined with standardized CT protocols results in a significant reduction of patient radiation dose in routine chest and abdominal CT examinations. Importantly, these dose reductions were achieved without compromising image quality, diagnostic confidence, or the need for repeat scans. The findings highlight the critical role of protocol standardization and patient-specific exposure modulation in enhancing radiation safety while maintaining high-quality diagnostic imaging. Routine implementation of these strategies supports best practices in clinical CT imaging and reinforces the principle of ALARA (As Low As Reasonably Achievable), ensuring safer and more efficient radiological care.

DECLARATION

Ethics Approval and Consent: This study was conducted after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants prior to inclusion in the study.

Availability of Data and Materials: The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

Conflict of Interests: The authors declare no competing interests.

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Authors' Contributions: All authors contributed to the study conception, design, data acquisition, analysis, and manuscript drafting. All authors read and approved the final manuscript

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