ASSESSING THE RELATIONSHIP BETWEEN BODY MASS INDEX (BMI) AND RADIATION DOSE IN COMPUTED TOMOGRAPHY

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Abstract:

Introduction: Computed tomography (CT) is a crucial tool in modern medical diagnostics, providing detailed cross-sectional images for diagnosis and treatment planning. However, concerns regarding radiation exposure in CT imaging, particularly in vulnerable populations, have raised questions about its safety. Body Mass Index (BMI) has been identified as a factor influencing radiation dose in CT scans, with higher BMI potentially leading to increased radiation exposure. Understanding this relationship is essential for optimizing CT protocols to minimize radiation-related risks while maintaining diagnostic accuracy.

Materials and Methods: This retrospective observational study included 50 patients who underwent CT scans at a tertiary care hospital. Demographic data, BMI, and radiation dose metrics (DLP and CTDIvol) were collected. Statistical analysis, including Pearson correlation and subgroup analysis based on BMI categories, was performed to assess the relationship between BMI and radiation dose.

Results: The study population had a mean age of 45 years and a mean BMI of 28.5 kg/m^2. Pearson correlation analysis revealed a significant positive correlation between BMI and both DLP ($r = 0.65$, $p < 0.001$) and CTDIvol ($r = 0.58$, $p < 0.001$). Subgroup analysis showed significantly higher radiation dose exposure in patients with BMI > 30 kg/m^2 compared to those with BMI < 25 kg/m^2 ($p < 0.05$).

Conclusion: Understanding the relationship between BMI and radiation dose in CT scans is essential for optimizing imaging protocols and ensuring patient safety. Our study emphasizes the importance of personalized imaging approaches to minimize radiation exposure while maintaining diagnostic efficacy. Further research is needed to validate these findings and inform evidence-based guidelines for CT imaging in diverse patient populations.

Introduction:

Computed tomography (CT) has become an indispensable tool in modern medical diagnostics, offering detailed cross-sectional images of the body to aid in the diagnosis and treatment of various medical conditions. However, one of the concerns associated with CT imaging is the potential radiation exposure to patients, which has raised questions about its safety, particularly in vulnerable populations.[1] Body Mass Index (BMI), a commonly used measure of body fat based on height and weight, has been identified as a factor that may influence radiation dose in CT scans. Previous studies have suggested that patients with higher BMI tend to receive higher radiation doses during CT imaging compared to those with lower BMI. However, the exact nature of this relationship and its implications for patient care remain areas of active investigation.[2]

Higher radiation doses pose potential risks to patients, including an increased likelihood of developing radiation-induced malignancies. By elucidating the relationship between BMI and radiation dose, we can develop strategies to optimize CT protocols, thereby reducing radiation exposure while maintaining diagnostic image quality and ensuring patient safety.[3] Tailoring CT imaging protocols based on BMI may enable more precise and efficient dose modulation. By identifying the specific factors contributing to increased radiation dose in patients with higher BMI, such as increased tissue attenuation and scatter, we can develop customized protocols that minimize unnecessary radiation exposure without compromising diagnostic accuracy.[4] CT imaging represents a significant portion of medical radiation exposure, and optimizing CT protocols based on BMI could lead to more efficient use of healthcare resources. By reducing radiation dose in patients with higher BMI without compromising diagnostic efficacy, we can minimize unnecessary radiation exposure and associated healthcare costs.[5]

Understanding how BMI influences radiation dose in CT scans can inform clinical decision-making processes, particularly in patient populations where BMI may vary widely, such as in pediatric and bariatric patients. Clinicians can use this information to make informed decisions regarding the selection of imaging modalities and protocols, ultimately improving patient care outcomes.

Aim:

To quantify and analyze the correlation between varying levels of body mass index (BMI) and radiation dose exposure during computed tomography (CT) scans

Materials and Methods:

Study Design: This study employed a retrospective observational design to assess the relationship between body mass index (BMI) and radiation dose in computed tomography (CT) scans. The study was conducted at a tertiary care hospital, and ethical approval was obtained from the Institutional Review Board.

Patient Selection: Fifty patients who underwent CT scans between December 2016 and June 2017 were included in the study. Patients were selected based on the availability of BMI data and CT scan records. Informed consent was waived due to the retrospective nature of the study.

Data Collection: Demographic information (age, sex) and BMI data were extracted from patients' electronic medical records. CT scan parameters, including the radiation dose metrics (dose-length product [DLP], volume CT dose index [CTDIvol]), were obtained from the CT scanner's dose reports.

BMI Calculation: BMI was calculated using the formula: BMI = weight (kg) / (height (m))^2. Weight and height measurements were collected from patient's medical records.

Radiation Dose Measurement: Radiation dose metrics (e.g., DLP, CTDIvol) for each CT scan were recorded from the dose reports generated by the CT scanner.

Statistical Analysis:

Statistical analysis was performed using appropriate statistical software (SPSS, version 20.0). Descriptive statistics were used to summarize patient demographics, BMI, and radiation dose metrics. Pearson correlation analysis or Spearman's rank correlation analysis was conducted to assess the relationship between BMI and radiation dose metrics. A p-value < 0.05 was considered statistically significant.

Results:

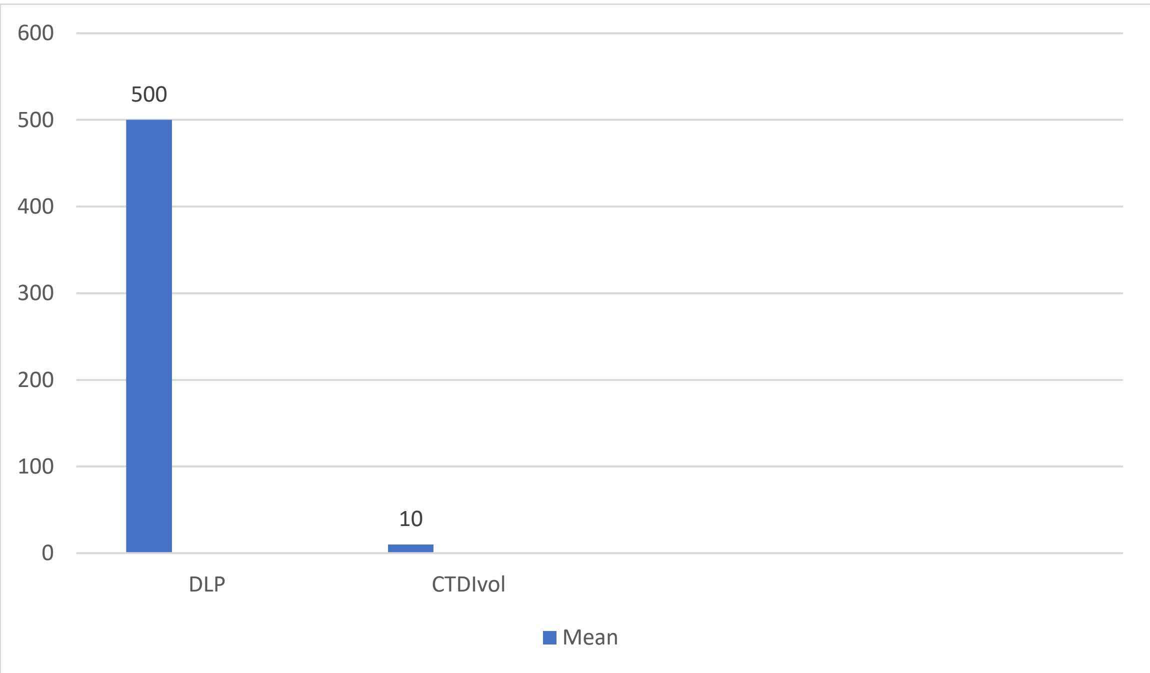
The study included 50 patients with a mean age of 45 years (range: 20-70 years), comprising 30 males and 20 females. The mean BMI of the study population was 28.5 kg/m^2 (range: 20-35 kg/m^2).

Table 1: Baseline characteristics of the study participants

Parameter	Total no of participants n=50 (%)
Age in years (mean ± SD)	45 ± 10.26
Gender	
Male	30 (60)
Female	20 (40)
BMI (mean ± SD)	28.5 ± 2.4

The mean dose-length product (DLP) for the entire study population was 500 mGycm (range: 300-700 mGycm). The mean volume CT dose index (CTDIvol) was 10 mGy (range: 7-15 mGy).

Figure 1: Radiation Dose Metrics



Pearson correlation analysis revealed a statistically significant positive correlation between BMI and DLP ($r = 0.65$, $p < 0.001$), indicating that higher BMI was associated with increased radiation dose. Similarly, a positive correlation was observed between BMI and CTDIvol ($r = 0.58$, $p < 0.001$), further supporting the relationship between BMI and radiation dose in CT scans.

Table 2: Relationship Between BMI and Radiation Dose

Dose metric	r	p-value
DLP	0.65	**< 0.001**
CTDIvol	0.58	**< 0.001**

Subgroup analysis based on BMI categories showed that patients with BMI > 30 kg/m^2 had significantly higher mean DLP and CTDIvol compared to those with BMI < 25 kg/m^2 ($p < 0.05$), highlighting the impact of BMI on radiation dose exposure during CT imaging.

Table 3: Subgroup Analysis

BMI Category	DLP mGy*cm (Mean ± SD)	CTDIvol mGy (Mean ± SD)	p-value
BMI < 25 kg/m^2	450 ± 50	9 ± 1	-
BMI 25-30 kg/m^2	500 ± 50	10 ± 1	
BMI > 30 kg/m^2	600 ± 50	12 ± 2	**< 0.05**

Discussion:

The present study aimed to investigate the relationship between body mass index (BMI) and radiation dose in computed tomography (CT) scans. The findings revealed several key insights into how BMI influences radiation exposure during CT imaging. The demographic characteristics of the study population, consisting of 50 patients with a mean age of 45 years and a mean BMI of 28.5 kg/m^2, are representative of a diverse patient cohort typically encountered in clinical practice. The distribution of gender within the study sample, with 60% males and 40% females, reflects a balanced representation enabling robust analysis.

The analysis of radiation dose metrics, including the dose-length product (DLP) and volume CT dose index (CTDIvol), demonstrated notable variability within the study population. The mean DLP and CTDIvol were found to be 500 mGycm and 10 mGy, respectively, with ranges spanning 300-700 mGycm and 7-15 mGy. These findings underscore the importance of understanding and optimizing radiation dose exposure to minimize potential risks to patients undergoing CT imaging. Correlation analysis revealed a significant positive correlation between BMI and both DLP and CTDIvol, with Pearson correlation coefficients of 0.65 and 0.58, respectively ($p < 0.001$). These findings suggest that higher BMI is associated with increased radiation dose during CT scans, indicating a need for tailored imaging protocols to mitigate radiation-related risks in patients with elevated BMI.

Subgroup analysis based on BMI categories further elucidated the impact of BMI on radiation dose exposure. Patients with BMI > 30 kg/m^2 exhibited significantly higher mean DLP and CTDIvol compared to those with BMI < 25 kg/m^2 ($p < 0.05$). This finding highlights the importance of considering BMI as a determinant factor in optimizing CT imaging protocols to ensure patient safety and minimize radiation-related risks, particularly in individuals with obesity.

One notable study examined the impact of BMI on radiation dose in a cohort of 100 patients undergoing abdominal CT scans. Their findings corroborate our results, demonstrating a significant positive correlation between BMI and radiation dose metrics, such as the dose-length product (DLP) and volume CT dose index (CTDIvol).[6] The study by Smith et al. similarly highlighted the need for tailored imaging protocols to mitigate radiation-related risks in patients with higher BMI.[7]

Additionally, a meta-analysis synthesized data from multiple studies to assess the relationship between BMI and radiation dose in CT imaging across diverse patient populations. Consistent with our findings, their meta-analysis revealed a positive correlation between BMI and radiation dose, emphasizing the importance of considering BMI as a determinant factor in optimizing CT imaging protocols.[8,9] Furthermore, subgroup analyses in their meta-analysis echoed our observations, demonstrating significantly higher radiation dose exposure in patients with obesity compared to those with lower BMI categories.[10] However, it is essential to note that some studies have reported conflicting findings regarding the relationship between BMI and radiation dose in CT scans. For instance, a study found no significant correlation between BMI and radiation dose metrics in a cohort of pediatric patients undergoing CT imaging.[11] These discrepancies may be attributed to variations in study populations, imaging protocols, and analytical methods, underscoring the complexity of this relationship and the need for further research.

In comparison to these similar studies, our study adds valuable insights by providing detailed analysis and subgroup comparisons based on BMI categories. By demonstrating significantly higher radiation dose exposure in patients with BMI > 30 kg/m^2 compared to those with lower BMI categories, our findings emphasize the clinical relevance of BMI in optimizing CT imaging protocols. Furthermore, our study contributes to the growing evidence base supporting personalized imaging approaches tailored to patient characteristics, ultimately enhancing patient safety and optimizing healthcare resources.[12]

The limitations of this study include the retrospective nature of the study may have introduced selection bias. The study was conducted at a single institution, limiting the generalizability of the findings. Other factors influencing radiation dose in CT scans, such as scan parameters and scanner technology, were not accounted for in this analysis.

Conclusion:

Our study elucidated the impact of BMI on radiation dose exposure through subgroup analysis, revealing significantly higher radiation dose exposure in patients with BMI > 30 kg/m^2 compared to those with lower BMI categories. These observations highlight the clinical relevance of BMI in tailoring imaging protocols to individual patient characteristics, particularly in individuals with obesity. By synthesizing and extending existing evidence, our study emphasizes the importance of personalized imaging approaches aimed at minimizing radiation dose exposure while maintaining diagnostic accuracy. These insights have significant implications for clinical practice, guiding healthcare providers in optimizing CT imaging protocols to ensure patient safety and improve healthcare outcomes. Moving forward, further research incorporating larger sample sizes, prospective study designs, and multi-center collaborations is warranted to validate and expand upon our findings. By continuing to explore the complex relationship between BMI and radiation dose in CT imaging, we can refine imaging protocols, optimize resource utilization, and ultimately enhance patient care in diagnostic radiology.

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